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THE MAY SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

ADMIRAL PEARY, THE DISCOVERER OF THE NORTH POLE. PROFESSOR WILLIAM HERBERT HOBBS 391
SOUND IN OCEAN SURVEYS. CAPTAIN N. H. HECK 400
SIAM IN MAY. PROFESSOR A. S. PEARSE 405
HOW RATS TRANSPORT EGGS. DR. E. W. GUDGER 415
WILD LIFE OF THE FOREST CARPET. ARTHUR PAUL JACOT 425
SOME OLD BIZARRE MEDICAL REMEDIES. DR. HARTWIN A. SCHULZE 431
TERRITORIAL EXPANSION. PROFESSOR STEPHEN S. VISHER 440
SCIENCE AND THE LAYMAN. DR. BENJAMIN C. GRUENBERG 450
SCIENCE SERVICE RADIO TALKS:
THE FORGOTTEN AGE OF CHILDHOOD. DR. P. H. FURFEY 458
STELLAR GUESTS. DR. F. ZWICKY 461
THE MAGIC AGE OF ALLOYS. A. B. PARSONS 465
THE BIOLOGICAL IMPORTANCE OF PRESSURE. DR. MCKEEN CATTELL 468
THE PROGRESS OF SCIENCE:
Michael Idvorsky Pupin, An Appreciation; Dr. Harlow Shapley and Dr. Ambrose Swasey; The Soil Mechanics Laboratory at Harvard University; The Fall of a Giant Sequoia; Atmospheric Acoustics and the Weather 476

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THE SCIENTIFIC MONTHLY

MAY, 1935

ADMIRAL PEARY, THE DISCOVERER OF THE NORTH POLE

By Professor WILLIAM HERBERT HOBBS

DIRECTOR OF THE GREENLAND EXPEDITIONS OF THE UNIVERSITY OF MICHIGAN

THE year 1934 marks the quarter-centennial of the discovery of the North Pole on April 6, 1909, by Robert Edwin Peary, after three centuries of the keenest international rivalry. This final conquest by the famous American explorer, after fate had intervened to frustrate his best endeavors throughout no less than twenty-three years of Arctic struggle, was regarded as so outstanding a milestone in the forward march of our nation and of the race that the President of the United States, the Honorable William Howard Taft, in his second annual message to the Congress, referred to the achievement in the following paragraph:

> The complete success of our country in Arctic Exploration should not remain unnoticed. . . . The unparalleled accomplishment of an American in reaching the North Pole, April 6, 1909, approved by the most expert scientists, has added to the distinction of our Navy, to which he belongs, and reflects credit upon his country. His unique success has received generous acknowledgment from scientific bodies and institutions of learning in Europe and America. I recommend fitting recognition by Congress of the great achievement of Robert Edwin Peary.

After a committee had made an exhaustive study of his narrative and observations, by concurrent action the two houses of Congress awarded Peary an official vote of thanks with a recommendation that he be elevated from the rank of commander to that of rear admiral in the United States Navy, and this appointment was made by the President.

The international significance of Peary's conquest of the Pole was indicated when every geographical society of note throughout Europe and America awarded him their most distinguished medal, decoration or other appropriate honor, such as had been done in the case of no other explorer in the history of the world. It was an outstanding example of recognition of merit which took no account of national boundaries.

Unfortunately, the return of the discoverer from the scene of his greatest achievement had been marked by the perpetration of the most stupendous public swindle in the history of science. This was the claim set up by a rival explorer that without any considerable preparation or adequate equipment he had arrived at the Pole and was the real discoverer, since he was there nearly a year earlier than Peary. As a result of this astounding assertion, which the general public was in no position to examine critically, this rival claimant throughout a period measured in months spoke before vast audiences throughout the United States and reaped a great harvest from the box office before his so-called observations were at long last submitted

ROBERT EDWIN PEARY

A PHOTOGRAPH TAKEN IN THE AUTHOR'S OFFICE AT ANN ARBOR IN 1915.

to a scientific council of his own choosing in Copenhagen. They were then found to be entirely worthless, and "Dr. Cook" thus became a byword for swindler throughout two continents.

The attainment of the Pole by Peary was achieved as the result of a matured plan which had been built upon earlier defeats and was executed with masterful generalship, but with hazards due to caprices of weather over which only the favor of fortune could prevail; and this for once was accorded him. As an exhibition of personal prowess in endurance of hardship and toil under adverse physical conditions, the successful polar expedition of 1909 in no way equalled his earlier northern conquests, such as the two double crossings of North Greenland in 1892 and 1895, or the circuit of the entire North Greenland coast in 1900.

For each of these three great achievements, which had astounded the world, so much did they surpass by their long marches all earlier dog-sled journeys, the irrefutable proofs that the goals claimed to have been reached were actually attained stand ready at hand. These proofs lie in the precious autographed records deposited by Peary within cairns—piles of stone in pyramidal form—which he had erected at significant points and at all places where he had turned back to his base. In every case without a single exception these precious records have been subsequently found in the places claimed, and either copied, photographed or brought back to civilization by some well-known explorer, who thus supplied the proof that he also had attained a goal of the great Peary.

In the case of the North Pole no such proof could possibly be supplied unless a later explorer were to follow close upon the heels of the earlier; for the North Pole lies in the midst of a frozen sea on the surface of which the ice floes are shifted about with each strong wind. As well might one deposit a record in a boat adrift in the open sea as upon the sea ice of the Arctic Ocean. One would be about as likely to be found as the other. The extreme probability, amounting almost to a certainty, that Peary reached the close proximity of the Pole lies in many important considerations, not the least of which was the high sense of honor of the man, recognized by all his contemporaries in exploration who were familiar with his record. Said Dr. W. S. Bruce, one of the great Antarctic explorers: "I feel sure if Peary says he was at the Pole, then *he was there.*"

Long before Peary had attained the Pole the great Arctic explorer, Fridtjof Nansen, remarked to Theodore Roosevelt, "Peary is your best man; in fact I think he is on the whole the best of the men now trying to reach the Pole, and there is a good chance that he will be the one to succeed." When in 1908 Peary departed on the *Roosevelt* for his last and successful attempt to reach the Pole, Theodore Roosevelt said as he grasped the great explorer's hand, "Peary, I believe in you and I believe in your success." It was Roosevelt who wrote the introduction to Peary's book, "The North Pole," which he concluded with these words:

> Commander Peary has made all dwellers in the civilized world his debtors; but, above all, we, his fellow Americans, are his debtors. He has performed one of the great feats of our time; he has won high honor for himself and for his country.

Again we have the supporting testimony of all the members of his expedition. Of the successful polar party were such well-known explorers as Bartlett, MacMillan and Borup, each in charge of a supporting party; and in the polar party itself the Negro Matt Henson and the four picked Eskimos—Ootah, Ooqueah, Egingwah and Seegloo. It

CAPTAIN R. A. BARTLETT
COMMANDER OF THE *Roosevelt*, WHO COMMANDED THE LAST SUPPORTING PARTY ON THE POLAR TRIP AND TURNED BACK AT LATITUDE 87° 47′.

would have been desirable to have had a white man of the polar party, and Peary would certainly have taken Bartlett had it been at all possible. It was, however, absolutely necessary that a navigator should lead the Eskimos of the last supporting party back to the base; for if a storm such as that which shifted Peary's party of the preceding expedition sixty miles eastward were to break out on the return, the party would almost to a certainty be lost. Moreover, Peary clearly considered the not remote possibility that he might himself never return, and he desired that the record to latitude 87° 47′ should not be lost.

The noteworthy increase in the daily marches after Bartlett's departure has been often commented upon, and by hostile critics has been exaggerated so as to discredit Peary's narrative. To all such criticism, the facts give a complete and satisfactory answer.

First of all, the fundamental plan called for just such a dash from the most advanced base and Peary and the men, who from the start seemed likely to form the polar party on the basis of their superior qualities, had throughout been spared much of the gruelling work of the earlier stages so as to keep in condition. In the second place the condition of the sea ice improves steadily as the distance from the land increases, and after passing latitude 84° or 85° N. on Peary's course it takes on the less hummocky character of the ice east of Greenland, and is in fact spoken of as *Atlantic* ice, whereas the old hummocky ice south of that latitude is known as *paleocrystic* ice. For the last six days before the departure of Bartlett, the double group of sledge parties made average daily marches of about nineteen miles.

Quite as important as the change in the ice-surface was the change in the morale of both Eskimos and dogs once their faces were turned toward home, as is known to all who have experience with these people. Eskimos are very fearful of venturing far out on either sea ice or inland ice, and Bartlett, who pioneered throughout, has related how he would wait for the Eskimos to come up and sometimes go back and find them sitting idly on the sledges—"soldiering." They felt safe if they were near *Pearyarksuah* (the Great Peary), whom they almost worshipped and whom they trusted beyond all precedent.

It is a mistake to assume, as many have done, that the men walked. Wherever the trail was good, and from the Pole it was clearly marked throughout, the men generally rode upon the sledges while the dogs for much of the time raced for home throughout long marches when the greatest difficulty was to keep from falling asleep and dropping out on the trail. Where no trail is in sight dogs are driven with the whip, but over a marked trail, and especially one they know, they need no encouragement if in good condition. No attention was paid to day or night hours, as it was always light enough for travel, but the already built igloos along the trail were used for sleeping whenever necessary. There had been unexpected delays going poleward,

and Peary was fearful that, because of the lateness of the season and the arrival of the spring tides, the *big lead* would be found wide open to bar the return passage. This fear was upon the Eskimos, and when after the "big lead" had been crossed and the firm ice of the glacial fringe reached, they went fairly mad with delight now that the strain was over. Dancing and shouting, Ootah cried as he collapsed upon his sledge, "The devil is asleep or having trouble with his wife or we should never have come back so easily." Arrived at Cape Columbia, whence the expedition had started out over the sea ice, the party slept for two days to make up for that which had been lost on the homeward journey.

It should not be lost sight of that Peary was the most expert dog sledger of his day. When after the long sled journeys across and around Greenland nearly a score of years earlier, he had received from the Royal Geographical Society in London the coveted Patron's Gold Medal, the president, Sir Clements Markham, had said:

> Lieut. Peary stands quite apart. . . . His journey with the dogs over 1200 miles on the inland ice of Greenland is unequalled. . . .

The dash to the Pole and back from latitude 88° was made with the pick of the dogs and drivers of the entire Eskimo tribe, and Henson after eighteen years of experience was the equal of any Eskimo. Yet the average marches of the party over sea ice have been many times surpassed, not only by Peary but by many others. As one writer without knowledge of the matter has claimed in a sensational article that such speeds could not possibly be made, it may be well to institute some comparisons.

The average march of Peary northward to the point of Bartlett's departure reckons out as 12.8 miles, a figure which offers little basis for comparison with the average to the Pole after Bartlett's departure—26 miles—or with the average for the return—25.6 miles—for the reasons already given, and because the loads to latitude 88° were heavy, the trail was rough and had to be pioneered and improved, snow huts had to be built, and the large and relatively unwieldy party was then only slowly being "shaken down."

That the average marches during the dash to the Pole and back, outstanding as they were, were not without parallels in both earlier and later work should be clear from the following examples.

Before setting out on the Pole expedition Captain Bartlett had sledged with heavy loads from Cape Sheridan to Cape Columbia, a distance of 90 miles, in five marches, an average of 18 miles. The return journey with the dogs homeward bound and drawing light sledges, was made in one march of 90 miles. On the return from the Pole after two days' sleep at Cape Columbia, Peary made the

CAPTAIN PETER FREUCHEN

WHO BROUGHT PEARY'S RECORD AWAY FROM NAVY CLIFF. HE IS THE ONLY WHITE MAN WHO HAS BEEN THERE SINCE PEARY'S EXPEDITIONS OF 1892 AND 1895.

EXPLORERS AND GEOGRAPHERS AT THE COLOSSEUM IN ROME

WITH PEARY AND HIS FAMILY IN THE FRONT CENTER. THIS PHOTOGRAPH WAS TAKEN ON THE OCCASION OF THE MEETING OF THE TENTH INTERNATIONAL CONGRESS OF GEOGRAPHERS IN 1913. TO LEFT OF PEARY IN FRONT CENTER MARQUIS CAPELLI WITH ROBERT PEARY, JR., MRS. PEARY AND THE POLAR EXPLORERS BRUCE, STEFANSSON AND CAGNI.

same distance in two marches of 45 miles each. MacMillan and Borup on the return from Cape Morris Jesup to the *Roosevelt*, a distance of from 250 to 300 miles as traveled, covered the distance in eight marches, an average of 31 to 34 miles; though, instead of eight, the outward journey had required eighteen marches. Matt Henson, traveling the full twenty-four hours, once covered 100 miles in a single march.

Much more remarkable, however, in February, 1899, before the sun returned, Peary with both his feet frozen only six weeks before and the stumps of his amputated toes scarcely healed, sledged from Fort Conger to Cape D'Urville, a distance of over 200 miles, in eleven marches, an average of 20 miles, and in an average temperature of 53.5 degrees below zero. In March of 1902 he went from Cape Sabine to Fort Conger, a distance of from 250 to 300 miles as traveled, in twelve marches, an average of 21 to 25 miles; and he later covered the same distance again in 11 marches, an average of 22 to 27 miles. Belknap and Schmeling, of the Fifth University of Michigan Greenland Expedition, with only one season's experience in dog sledging, made an average march of 65 miles for four successive days, and on one day made no less than 80 miles. These are all nautical miles and over sea ice.

Gunnar Isaachsen says of the sledging on sea ice to the west of Grant Land, "We often made 20 to 30 miles and marches over 30 were not rare. Several times we made marches of over 70

miles." The wide variations are of course explained by the quality of the dogs, the ice conditions and the weight of the loads on the sledges. Peary left Bartlett for the Pole with moderate loads only, and on the return these loads were constantly diminishing.

Peary took infinite pains to furnish the proofs for his claim. On the route to the Pole a series of soundings was taken and one of these was within five miles of the Pole itself, where some thin ice suitable for cutting was fortunately found. Soundings, however, at best furnish a partial proof only if the sea bottom should later be found to be notably irregular. The only hope that they will be repeated lies in the Wilkins submarine expedition, for no explorer is likely again to repeat the hazardous journey across the sea ice.

Fortunately, however, the observations of the sun's altitude made by Peary at the Pole have as the result of a then unknown variation in the daily change rate of his standard chronometer supplied a convincing proof, as was pointed out by the distinguished computer of astronomical observations, Hugh C. Mitchell, to whom the polar observations of Peary after his return were submitted by the Committee of the National Geographic Society. The nature of this proof will therefore be stated.

Latitude is elsewhere obtained directly from the angular elevation of the sun measured against the horizon, either with a sextant or with a theodolite or a transit. Near the Pole the sun, when above the horizon, is at so low an angle that the horizon can not be seen, and an "artificial horizon" must be substituted —a level reflecting surface, such as a bath of mercury. It is necessary to take the sun's angle at intervals throughout the twenty-four hours; and if this is done at the Pole itself, the angles should agree throughout. From the variations of such readings the distance from the Pole may be determined.

Peary's observations, submitted to the committee of the Congress, were turned over to Hugh C. Mitchell and C. R. Duvall, the distinguished expert computers of astronomical observations of the U. S. Coast and Geodetic Survey. These technical experts, working independently of each other and employing different methods, obtained results which agreed within a second of angle for latitude. These give for the latitude of Peary's camp near the Pole, 89° 55′ 23″, and for the longitude 137° W. Hence the position of his camp (Camp Jesup) was 4.6 geographic miles distant from the Pole. But this was not Peary's closest approach to the Pole, for on the morning of April 7 at 6:40 o'clock, Peary traveled in the direction of the sun, immediately after taking his observations, for a distance of 8 miles, and so, as computed by the experts, he passed within a distance of 1.6 miles of the Pole. Further, Peary made trips of a few miles each in several different directions and it may be came within a stone's throw of the exact position of the Pole; but the point is one which has only an academic interest.

In his report Mitchell stated that from his professional experience he believed it would have been impossible for the data of these observations to have been obtained other than under the circumstances claimed. In using these observations in connection with each other, they in a measure prove each other; and error could be detected had the observations not been made at the points set forth in the data. The nature of this proof is not difficult to understand.

On the return from the Pole Peary's standard chronometer was sent to its makers for rating and comparison. When examined before the expedition

PEARY AND HIS FAMILY

AN ENLARGEMENT FROM THE PREVIOUS PHOTOGRAPH SHOWING FROM LEFT TO RIGHT, IN THE FRONT ROW: MARQUIS CAPELLI, PRESIDENT OF THE CONGRESS, WITH YOUNG ROBERT PEARY IN FRONT OF HIM; PEARY, MARIE PEARY STAFFORD (THE "SNOW BABY"), MRS. HOBBS, HOBBS, WOIKOFF AND WAGNER, DISTINGUISHED RUSSIAN AND GERMAN GEOGRAPHERS.

started the previous year, the makers had found it to have a *predicted* daily rate of two tenths of a second *losing*. On the return, however, the check-up showed that it had really had a daily rate of two and two tenths of a second *gaining*. Peary had taken at the Pole in all thirteen single, or six and one half double altitudes of the sun, at two different stations, in three different directions and at four different times. All except the first single altitude, taken on April 6, were under satisfactory conditions, and all at temperatures of $-11°$ F. to $-30°$ F., or above the freezing temperature of the mercury in the artificial horizon. At the time the observations were taken Peary *supposed* that his chronometer had been losing two tenths of a second daily, and as a consequence of the *actual* rate of 2.2 seconds gaining, he observed the sun for noon observation ten minutes before it was on the meridian. Mr. Mitchell states that the observations all show that the sun was actually where it must have been, not at the instants Peary at the time supposed, but at those which the behavior of the chronometer as later revealed indicated.

Some of the medals awarded Peary for his achievement of the Pole were: the Nachtigal gold medal of the Imperial German Geographical Society of Berlin, the Hauer gold medal of the Imperial Austrian Geographical Society of Vienna, the King Humbert gold medal of the Royal Italian Geographical Society of Rome, the gold medal of the Hungarian Geographical Society of Budapest, the award of the Royal Bel-

gian Geographical Society of Brussels, the gold medal of the Royal Geographical Society of Antwerp, a special silver trophy in the form of a ship from the Royal Scottish Geographical Society of Edinburgh, the Grand Cross of the Legion of Honor of France in Paris, both the Daly and the Cullum gold medals of the American Geographical Society of New York, the Hubbard gold medal of the National Geographic Society of Washington, the Kane gold medal of the Geographical Society of Philadelphia, the Culver gold medal of the Chicago Geographical Society, the gold medal of the Explorers' Club in New York and the medals from many municipal societies. The Royal Geographical Society of London at the time the Pole was reached had already awarded Peary for earlier expeditions the Patron's Gold Medal, and it was therefore decided to award him a great Special Gold Medal no less than three inches in diameter. Special gold medals had before been awarded but three times: a three-inch medal to Stanley in 1890 for the rescue of Emin Pasha and for the crossing of Africa, a two-and-a-half-inch medal to Nansen in 1897 for his great Arctic Expedition in the *Fram*, and a three-inch medal to Shackleton for his Antarctic Expeditions.

Other honors came to Peary in the election to the presidency of the American Geographical Society in 1903, to the presidency of the Eighth International Geographical Congress held in Washington in 1904, honorary vice-president of the Ninth International Geographical Congress held in Geneva in 1908, and of the tenth held in Rome in 1913. The honorary degree of doctor of laws was conferred upon Peary by the University of Edinburgh.

When the Great War broke out in Europe in 1914, Peary became actively interested in the defense of the country, and having early seen the importance of aircraft, he strove to secure for the Atlantic Coast a patrol by seaplanes. Always intensely patriotic, he threw himself heart and soul into the defense movement long before the President came to realize that America would be forced to abandon her position of neutrality and enter the war, and in this campaign Peary addressed large audiences on national defense.

The war ended, Peary soon became a victim of pernicious anemia before the now well-known means of combatting this dread disease had been discovered. For two years he fought its encroachments, in later stages with transfusions of blood, but in vain. He passed from life on February 20, 1920, at his home in Washington, and his body was lowered into the grave in Arlington Cemetery with full military honors. At the dedication of his monument there the President of the United States, the Chief Justice of the Supreme Court and those distinguished in many walks of life were present.

One of the greatest of all explorers, Peary was a great leader and a man of the highest sense of honor. By those who served under him he was almost worshipped, and he was loved and admired by those of a wider circle who were privileged to know him.

SOUND IN OCEAN SURVEYS

By Captain N. H. HECK

CHIEF OF THE DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY, U. S. COAST AND GEODETIC SURVEY

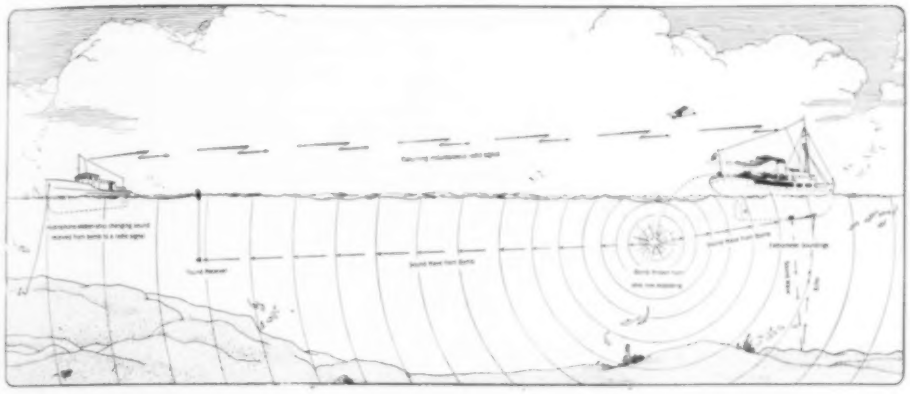
IF the Coast and Geodetic Survey were to change its official emblem to a flower, it could well be the narcissus. You may recall Narcissus as the youth who pursued that elusive nymph Echo, who had pined away until nothing remained but a voice which always repeated the last words uttered in the vicinity. Narcissus in turn mistook his own image in the pool for the lost Echo, and he also pined away and was changed into the flower which bears his name. This ancient Greek myth of Narcissus pursuing the echo, or of the reflection of sound and light, is appropriate, since either the echo or the one-way path of sound has become the basis of modern hydrographic surveying; and there is always the hope that the velocity of light can be used for the measurement of distances on earth as in the heavens.

The use of the velocity of sound to measure distances is not so old as the myth, but it is by no means new. The method is mentioned by Jules Verne in his "A Journey to the Center of the Earth," with an amusing error. The adventurers had followed different underground passageways and had become widely separated; then they arrived at positions where they heard each other's voices through the rock. One shouted, noting the time on his watch; the other on hearing the sound immediately replied, and the arrival of the sound was noted by the first observer, thus obtaining the time interval. The error made by the author was in assuming that the velocity of the sound is 1,120 feet per second through rock. Actually the distance would have been nearly 20 times as great as they supposed.

Early works on hydrographic surveying give the method of base measurement by sound through air. A gun was fired, and the observer, perhaps three miles away, carefully noted the interval of time between seeing the smoke and the arrival of the sound. Fairly good results were claimed if there were three or four repetitions, although there are various sources of error.

The first use of the velocity of sound in sea water as a means of measuring distance is credited to R. A. Fessenden, who accompanied a Coast Guard vessel on the International Ice Patrol to the Grand Banks in 1913 in an effort to determine whether icebergs could be located by acoustic methods. It is nowhere stated that he was successful, but he did succeed in obtaining echoes from the bottom and conceived the idea of depth determination by this method.

The world war stimulated the development of many acoustical devices, particularly the transmission, reception and the recording of underwater sound signals. Apparatus for acoustic or echo sounding was devised and has been steadily improved. Much of the improvement has come from the rigid demands of accuracy by the Coast and Geodetic Survey, and this has culminated in the Dorsey Fathometer, which measures accurately depths as small as a few feet. This is named for Dr. Herbert Grove Dorsey, who has been in immediate charge of the acoustical development work of the Coast and Geodetic Survey since 1926.



FATHOMETER SOUNDINGS AND RADIO ACOUSTIC RANGING

SHOWING TWO OF THE SCIENTIFIC METHODS EMPLOYED BY THE COAST AND GEODETIC SURVEY OF THE DEPARTMENT OF COMMERCE TO INSURE ON NAUTICAL CHARTS (1) CORRECT WATER DEPTHS AND (2) THE PRECISE POSITIONS OF SUCH DEPTHS, MANY OF WHICH ARE GIVEN FOR WATER AREAS FAR OUT OF SIGHT OF LAND. DEPTHS ARE DETERMINED WITH A FATHOMETER, WHICH MEASURES THE TIME REQUIRED FOR A SOUND TO TRAVEL TO THE SEA BOTTOM AND RETURN TO THE SHIP AS AN ECHO. THEY ARE MADE AT THE RATE OF 4 PER SECOND, WHILE THE SURVEY SHIP PROCEEDS BACK AND FORTH OVER THE AREA AT HER REGULAR SPEED. THE POSITIONS OF THESE DEPTHS ARE FIXED BY RADIO ACOUSTIC RANGING, FROM TWO PREVIOUSLY DETERMINED POSITIONS, SUCH AS TWO STATION SHIPS (OF WHICH ONE IS SHOWN). THE TIME ELAPSED BETWEEN THE SOUND FROM THE BOMB AS RECEIVED ON THE SURVEY VESSEL, AND THE RADIO WAVE FROM THE STATION SHIPS, IS MEASURED ON THE SURVEYING SHIP TO ONE ONE-HUNDREDTH OF A SECOND. KNOWING THE VELOCITY OF SOUND IN WATER, THE DISTANCE BETWEEN THE SURVEY SHIP AND EACH OF THE TWO STATION SHIPS CAN BE CALCULATED ACCURATELY, EVEN WHEN SEPARATED BY AS MUCH AS 100 MILES.

The demands of surveying have resulted in better instruments for acoustic sounding in navigation than would have otherwise been likely. The use of the method in navigation has changed the demands on the charts, for although some accurate soundings out of sight of land have always been required, the new method requires much more complete detail of the submarine configuration. Now, vessels frequently obtain their positions by recording a line of soundings over some characteristic detail of the ocean bottom and comparing these soundings with the chart. This method of navigation has emphasized another problem of equal importance to the actual sounding—obtaining an accurate position of the surveying vessel when objects on shore are invisible, due to distance or night or fog. A survey of the continental shelf of the Atlantic Coast of the United States had been started by precise dead reckoning just prior to the development of acoustic methods. This, while better than previous methods for obtaining the position of the surveying vessel, still left much to be desired in accuracy. Similar surveys on the Pacific Coast were complicated by the heavy fogs and strong currents, and work of acceptable accuracy was limited to areas within sight of land and in clear weather. Under any other conditions, the slow-moving surveying vessels which had to stop frequently for wire soundings were at the mercy of the vagaries of wind and current, and in consequence little reliance could be placed on their position.

The radio compass suggested a possi-

ble solution, but while very useful in navigation, it was found not to have the accuracy required in surveying.

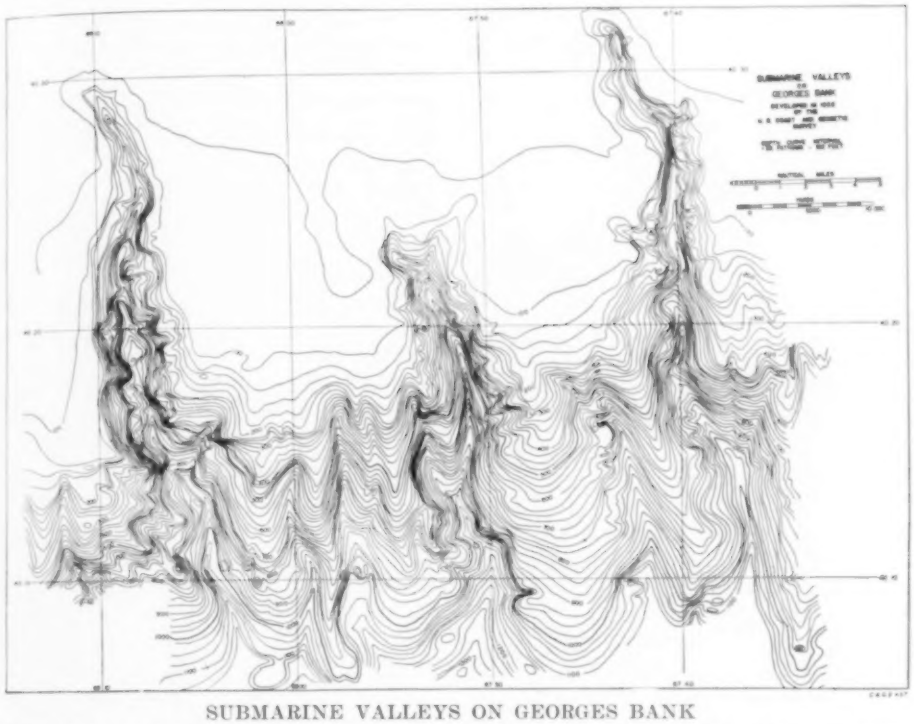
To meet these conditions, radio acoustic ranging was developed in 1923 by the Coast and Geodetic Survey, the apparatus being constructed and tested by the National Bureau of Standards. Previous work had been done by the British, but in no case had the feature which is largely responsible for the effectiveness of the method—recording aboard the surveying vessel—been adopted. After some tests at New London, Connecticut, in which officers of the Coast Artillery, U. S. Army, gave aid and advice, the work was transferred to San Diego, California. The writer, who had become familiar with this general type of work through naval anti-submarine duty during the world war, was associated with the development of radio acoustic ranging during its first year. The method was put into actual use during 1924. During the first years of development, there were several failures and some of the results had to be rejected, but by 1927 the new method had revolutionized all previous ideas of possible quantity and quality of results.

While the practical difficulties that caused this delay were great, the fundamental idea is simple. A bomb is fired near the surveying vessel, which is proceeding at full speed. A recorder somewhat resembling a stock ticker records on its tape the instant the impulse from the explosion reaches the ship's hydrophones, which are part of the acoustic sounding apparatus. In the meantime, the sound wave travels through the water until it reaches an underwater hydrophone connected by a cable to a shore station, where the arriving impulse is amplified and operates a thyratron, sending back a radio signal to be recorded on the same tape. The time interval thus is obtained to within one one-hundredth of a second, and this time interval with the velocity of sound along the path followed by the sound wave gives the ship's distance from the hydrophone. With two such distances to suitably placed hydrophones, the intersection gives the ship's position.

Assuming that we have the time interval to the required accuracy, there are two other important considerations—the velocity of sound and the path of the wave. If the sound wave traveled at a uniform velocity in a straight line, the problem would be quite simple. It appears from recent investigation that it probably travels by a series of reflections between the surface and bottom of the ocean, except in very deep water where it does not reach the bottom. Since the elastic and inertia constants of the sea vary with temperature and density, the velocity undergoes seasonal variations.

The theoretical velocities must be verified on the working grounds by comparison with some distance which is directly measured, *e.g.*, by taking visual fixes on shore objects that have been determined by triangulation, or by comparing the fathometer soundings with a direct measurement to the bottom with a steel wire. Many additional checks are applied daily to insure that the soundings and the features of the chart are correct in all detail.

Early studies of the velocity of sound include those of Colladon and Sturm in 1827. In this case the sound source was a submarine bell. More careful measurements were made by Threlfall and Adair in Australia in 1899, using explosives and electrical instruments and there have been various isolated measurements. The cruise of the Coast and Geodetic Survey ship *Guide* in 1923–24 from New London, Connecticut, to San Diego, California, via Puerto Rico and the Panama Canal, during which a very wide range of depth was encountered up to the greatest found in the Atlantic



SUBMARINE VALLEYS ON GEORGES BANK

THESE VALLEYS ARE BEING STUDIED BY OCEANOGRAPHERS AND GEOLOGISTS IN CONNECTION WITH THE ORIGIN OF THE CONTINENTAL SHELVES AND OTHER INTERESTING GEOLOGICAL PROBLEMS.

Ocean, resulted in the first accurate comprehensive velocity tables. These were compiled by Heck and Service immediately following the cruise. A little later, the British Admiralty published another set of tables, which differ slightly from those of Heck and Service.

One great advantage of this system of position determination is that the vessel is able, without effect on accuracy of subsequent work, to stop at regular intervals for wire soundings, to determine temperatures, secure water samples for determination of salinity and to obtain samples of the bottom. This information is in part needed for selecting the correct velocity of sound, but it is also useful to the physical oceanographer and the geologist.

When this method was first applied on the Atlantic Coast, it was found that shore stations could not be used. In order that the cables might not be of excessive length, the hydrophones have to be placed in very shoal water, and probably on account of loss of energy with multiple reflections, the sound does not go through. The use of two station ships solved this problem.

One important result was the survey of Georges Bank, which extends to 150 miles eastward of Cape Cod. In order to locate the station ships it was necessary to carry out a new kind of triangulation. Buoys were placed on the bank in such positions as to form a series of triangles or rather quadrilaterals which eventually formed a triangulation net over the entire area. The first buoys near the eastern extremity of the bank were located by precise astronomical observations, and these were connected

through to buoys in sight of the shore by measuring the sides and diagonals of the quadrilaterals by radio acoustic ranging. When the connection was made with the federal triangulation net on the shores, the error carried through this novel triangulation scheme proved to be surprisingly small.

During the past year by a combination of radio acoustic ranging and the British taut wire apparatus, even greater accuracy has been obtained. The taut wire apparatus consists of a large reel of steel piano wire mounted on the surveying vessel with registering sheave and suitable control, so that the wire can be readily payed out as the vessel steams along. To measure a distance as between two buoys, the end of the wire is anchored near one of the buoys and when the other buoy is reached, the sheave reading gives the distance with all required accuracy if the bottom is reasonably uniform. The combination of the two methods has resulted in even greater efficiency and reduced cost.

The purpose of these developments has been to produce charts which meet the needs of the mariner and add to the safety of life at sea, but there are important economic and scientific by-products. Fishing and the conservation and replacement of fish require accurate knowledge of the bottom. The Georges Bank charts have proved invaluable in this connection. The oceanographer needs accurate charts for many kinds of studies of the ocean, including the characteristics and circulation of the water. In geology, not only does the physiographer have a better understanding of what happens to the sediments which constantly leave the land, but the working area of the geologist has been extended to the edge of the continental shelf with accuracy comparable to that obtained on land. The finding of great gorges or submarine valleys has stimulated thought in regard to their possible origin. Accordingly work that was done to meet the needs of the mariner is aiding in revealing the history of the portion of the continent that is at present submerged beneath the sea.

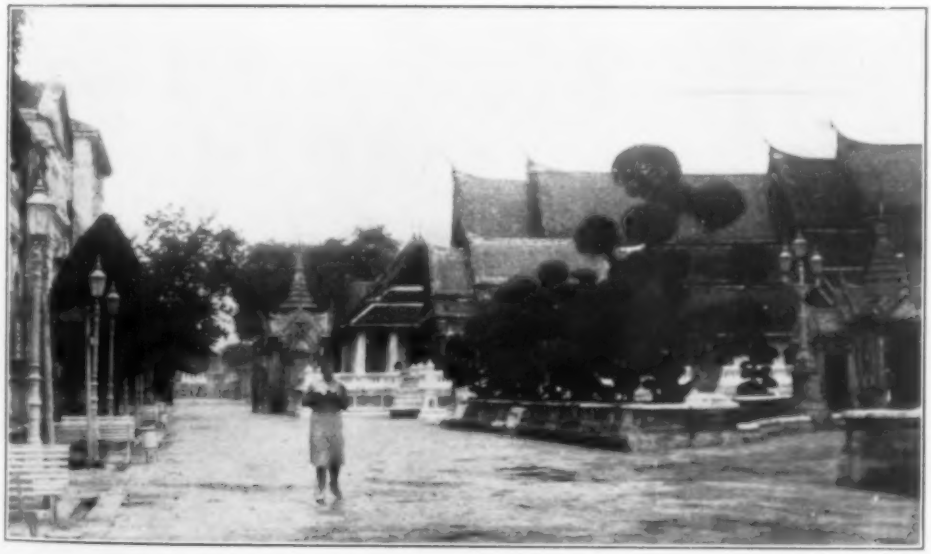
SIAM IN MAY

By Dr. A. S. PEARSE

PROFESSOR OF ZOOLOGY, DUKE UNIVERSITY

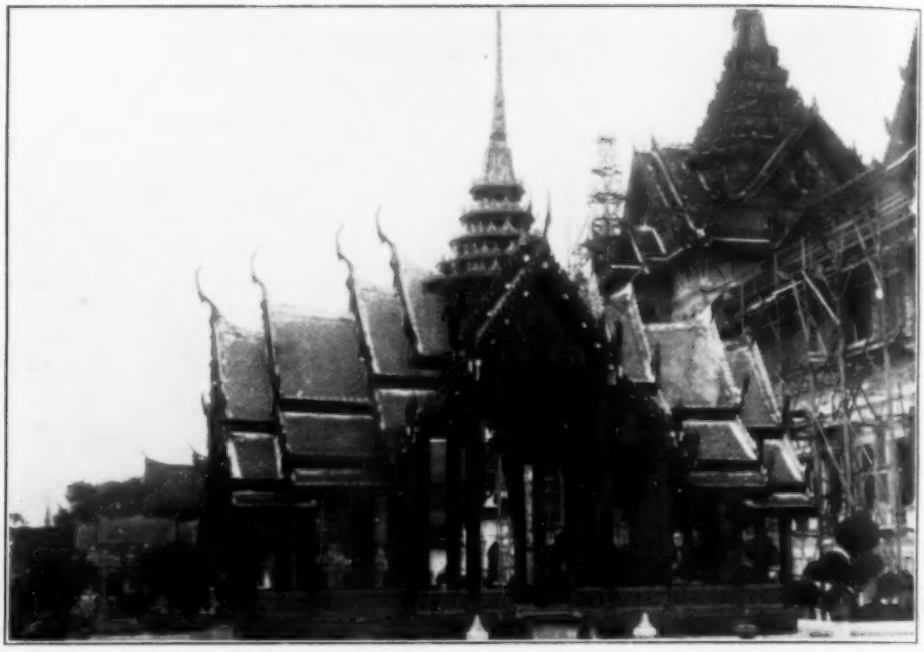
ONE goes by rail from Penang to Bangkok through a very picturesque country. Verdant buttes rise on either side of the railway. These have been beautifully eroded by nature, so that they are cleft and cavernous. Clumps of graceful toddy palms sway at the edges of fallow rice fields. These furnish wine and sugar for the Siamese. There are piles of cord wood at each station, for no coal is to be had and the fireman must work continually to keep up steam. Sitting in neat and well-appointed sleeping cars, a passenger roars through thatched villages. Now and then an elephant may be seen at his daily work. The gilded spires of Buddhist temples rise through the trees. Lotus blossoms make little wayside ponds charming.

Bangkok is perhaps the most fantastic city in the world. It is built along the banks of the Menam Chao Phya and its numerous klongs (canals) still serve as highways for most of its population, though modern roads also connect all parts of the city and are used by pedestrians, carts, rickishas and automobiles. Along the Menam for many miles there are pile-supported houses which can be reached only by water. Stores, post offices and residences bob up and down on flatboats. Little children and old women paddle about in boats that are no longer than themselves. The natives appreciate the "great mother of waters." They may be seen using her continually for transportation, bath, beverage, power and source of food. Rice boats ply back and forth. Great



A STREET BY THE ROYAL PALACE IN BANGKOK

SHRUBS ARE GENERALLY TRIMMED IN FANTASTIC FORMS.

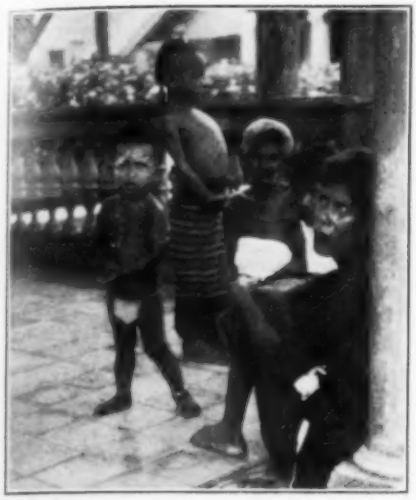


THE ROYAL PALACE

POINTS ON ROOF TREES EFFECTIVELY KEEP AWAY DEVILS.

rafts of teak float down from the forests in the interior. Handsome maids who live on barges dip up cups of water to drink or wash their teeth, and throw their household wastes into the long-enduring old mother. Dignified, modestly submerged dames with little nets dip up shrimps and drop them into floating pots while they gossip. Ferry boats of all sorts and sizes carry busy patrons. The sampans of farmers and fishermen are tied along the banks, while their owners offer their products for sale. Buddhist priests, clad only in startling yellow cloths, hold begging bowls. In the open field by the great palace grown men fly great kites. Wonderfully ornate palaces, temples and shrines rise above the roofs of the houses.

The Siamese, like most races, are something of a mixture. Their country has at various times been invaded and in part ruled by Burmese, Indians, Malays, Mons, Cambodians and Khmers, but the Siamese (Thai) came mostly from South China. Their general culture, as evident in literature, art and customs, has been influenced largely by India, and hence more remotely by Persia, but Siam has a culture all her own. The architecture and pictorial art are quite wonderful. Both men and women cut their hair short. The national costume includes a loose diaper, which is worn by both sexes. Hats which look like inverted dishpans are seen everywhere. The country is underpopulated, and perhaps on this account the people are disposed to be rather easy-going. The rice mills and other industries are largely in the hands of Chinese, and the Siamese laughingly say that they do not like hard work and are quite content to have it so. As one goes about every one he meets seems to be happy and con-



NATIVES OF SIAM

ABOVE, GIRLS AND BETEL CHEWERS; BELOW, MAKING PALM LEAF SHINGLES.

tented. The nobility are as a rule intelligent, educated and agreeable. The ambition of most peasants is to become attached to the household of some noble or wealthy man. The farmers are simple folk. Recent kings have for the most part been progressive and wise. Compulsory education is being rapidly extended to all parts of the country. Along with modern progressive trends some old and undesirable customs persist. Young men are required by law to serve two years in the army and three months as Buddhist priests before they reach the age of twenty-three. Women during childbirth are commonly tortured by being baked for hours beside hot fires. The chewing of a mixture of lime, the nut of the areca palm (betel nut; *Areca catchu* L.) and the leaves of the céri vine (*Piper betel* L.) makes the mouth and teeth of ordinary natives very hideous.

Though tin is mined extensively in southern Siam and a little gold occurs here and there, the chief resources are in native and cultivated plants and in aquatic animals. The extensive paddy fields in the alluvial plains are plowed with carabaos at the end of May and small rice plants from seed beds are planted. Palms and bamboos flourish in the lowlands; teak, rosewood and other valuable trees grow in the forests in the interior. Near water grows the attap

TEMPLE DOOR, BANGKOK

THE COLORS ARE TASTEFUL AND BEAUTIFUL.

A KLONG MARKET

FARMERS, FISHERMEN AND MERCHANTS OFFER GOODS FOR SALE.

palm, which is used to thatch houses. A variety of fruits is commonly eaten. The cocoanut furnishes a refreshing drink, white flesh and sugar. A variety of bananas, mangoes, papayas, lamut, pommelo, melons, rambutan, linchi, langstart, oranges and lovely mangosteens are in the markets. The mighty and malodorous durian and jackfruit will astound those who have not met them. Imagine a custard + garlic, with a dash of turpentine and castor oil, and

A STORE ON A KLONG

AN OLD LADY IS ARRIVING AT HER FRONT PORCH IN HER DUGOUT CANOE.

PLANTING

PLOWING

PLUMP DAMES WADE THROUGH MUD BEHIND CARABAOS.

A RICE BOAT

MANY SUCH BOATS CARRY RICE TO MILLS ALONG THE MENAM.

you have a durian. Yet those who have learned to like the prickly durian will have no other fruit and esteem it the "fruit of heaven." To my mind they are addicts.

Siam is an ideal place for the orchid hunter. There are also many beautiful flowering trees, among which the *ton pradu* (flamboyan, flame of the forest) never fails to charm. Roses, lotuses and jessamines flourish.

The fauna of Siam includes the elephant, tiger, leopard, boar, deer, gaur, rhinoceros, monkeys, gibbons, peacock, pheasants and other birds. Along the coast and in the streams and klongs a variety of fishes is to be found. The Mekhong is the home of the largest freshwater fish in Asia, the *pla buk*, which attains a weight of over 240 kilograms (530 pounds). The chief domestic animals are water buffaloes, humped-backed cattle, small Siamese ponies, pigs, ducks, geese and pariah dogs. In the markets near the coast various crabs, oysters and other sea foods are to be found.

For the naturalist Siam offers many opportunities. The seas, estuaries, rivers, klongs, rice paddies, fields, forests and mountains teem with life. At present Dr. H. M. Smith is scientific adviser for the Siamese government. He is making extensive collections and has already published several papers, especially in regard to fishes. In and near Bangkok he showed the writer several unique piscine spectacles. At his laboratory experiments are being conducted concerning the heredity of certain characters of the famous Siamese fighting fish. Specimens of this little fish are kept in separate glass jars with cardboards between. When a screen between two males is removed the pugnacious little fellows erect their fins; their bodies scintillate with a display of rainbow colors; and they bump their noses against the sides of their jars in frantic efforts to reach one another. When two males are placed together they fight until one of them is killed. Wrestling fishes have long beaks and two males will struggle for hours on end. Archer fishes shoot drops of water from their protuberant mouths and knock insects down to the surface from vegetation. A drop of water thus may be spit several feet with great precision.

In Siam there are more than twenty

A BOY AND GIRL ON A WATER WHEEL
SALTY WATER IS PUMPED ON ENCLOSED FLATS AND EVAPORATED TO OBTAIN SALT.

species of fishes which breathe air. These will drown in from half an hour to two hours if they are kept under water and thus prevented from gulping in air from the surface. They have accessory respiratory organs of various types. These usually lie in special chambers above the gills. The climbing perch, *Anabas testudineus* (Bloch), often leaves klongs during rains and at night. A man may go home from a bridge party and find one of these fishes catching grasshoppers on his lawn. The serpentheads also make long journeys overland and live for as much as four months in dry mud. A Siamese farmer

A FRUIT MARKET, WITH JACKFRUIT AND DURIAN IN THE FOREGROUND

often fishes by turning over his rice fields with a spade. He puts his catch of serpentheads in a bag and carries them to market. They may live there for days without water before they are sold. Various views have been held as to why in Siam and other tropical countries fishes have become air breathers, and periodic aridity has usually been supposed to be the primary factor in

WHERE MY MEALS CAME FROM; PAKNAM. DELECTABLE DRIED SQUIDS HANG BENEATH THE TREE

causing the necessary changes in structure and function. It has been shown, however, that in warm, shallow waters there is often a lack of oxygen and large amounts of carbon dioxide may be present, especially at night. So fishes are obliged to breathe near the surface or gulp in air. In Siam several species of fishes which never leave the water require air continually for their respiratory activities.

Cheerful, rotund, little Nai Pongse Phintuyotsin acted as guide and interpreter on a trip to Paknam at the mouth of the Menam Chao Phya, where we were able to study several species of beach-skipping gobies. These curious fishes live on mud-flats along the banks of rivers and dig holes in which they bring forth their young. There were three or four species of gobies which lived together at Paknam. A big fellow, *Periophthalmus barbatus* (L), lived largely on crabs and other fishes; a medium-sized goby, *Boleophthalmus bodaerti* (Pallas), gleaned filamentous algae for food by wagging its head from side to side over the surface of the mud; a little goby, *Periophthalmodon schlosseri* (Pallas), subsisted on mud, insects, such as ants, and little crustaceans. These gobies are adapted to life on land, especially in their locomotor and visual organs. They jump several feet and are very agile. Their eyes are unlike those of most fishes in being far-sighted, and are covered by a transparent protective membrane. Though beach-skippers drown if kept long under water, they can not live long in air without wetting their gills and branchial cavities. They are therefore at home on mucky flats, but often wander inland for a short distance among the attap palms or mangroves. After living where beach-skippers, climbing perch, serpentheads and crabs continually wander out of hot, shallow, oxygen-poor waters to take advantage of the high oxygen and food resources on land, it is easier to understand how aquatic animals gave rise to terrestrial types.

MAKING PALM LEAF SHINGLES

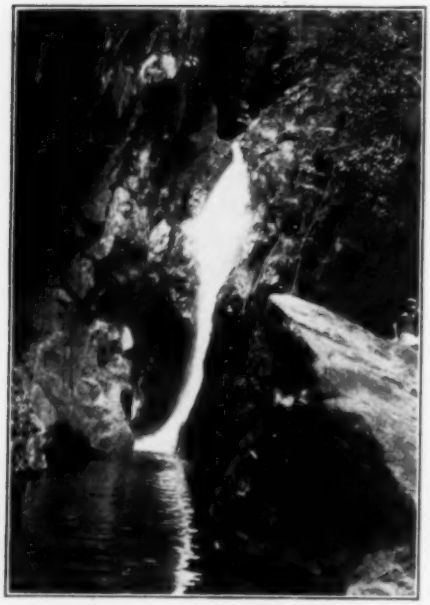
At Paknam we lodged with the governor's secretary and were courteously

received by his little wife, Laor. A traveler in Siam needs little but his bathing bowl and a cake of soap. Nai Pongse Phintuyotsin had a silver bowl ornamented with fantastic figures. I saved my face somewhat with an aluminum pan. With this each morn and eve I stood on the porch before a great jar of rain water and dashed refreshing showers over my soapy body. The children in the neighborhood always enjoyed this ceremony. My meals were delivered three times each day from a Chinese restaurant. The Chinese are born cooks, and I lived well.

The most wonderful experience I had in Siam was a trip to Koh Chang (Big Elephant), a Siamese island near the coast of Cambodia. Koh Chang is about thirty kilometers long and ten wide. It is covered by a luxuriant rain forest. With Siri Habanananda and Gordon Alexander I slept among cocoanut palms twenty feet above the ground on the bamboo porch of the stilted house of a benign bachelor. The customs officer sent in hot rice for each meal and, with a grub-stake of canned goods, we did very well; until two days before we left, when a nice-looking little boy stole all our food. The work of the customs official did not seem to be very arduous. There were few imports except smuggled opium, and most of his work was in collecting the taxes on bird nests and turtle's eggs. On the way to Koh Chang we stopped at Chantaboon, and in an hour ashore I collected two apodous amphibians under stones and several fungus-beds of termites.

On Koh Chang the animals in the forest were wonderful. Great snakes chased squealing rats among the trees. In the luxurious palms about our house were flying lizards (*Draco volans*). These curious saurians have ribs which expand so as to support a membrane along each side of the body. They are

THE BOY WHO STOLE OUR GRUB-STAKE
HE STANDS BETWEEN SPROUTING COCOANUTS.



A WATERFALL IN KOH CHANG

CHANTABOON AT SUNSET

thus able to volplane from one tree to another. The dracos clung tightly to trunks even after I had shot them. To secure specimens I often had to use a long bamboo pole.

Along the mountain trails on Koh Chang were many land leeches. These lurked under leaves, and when one passed they emerged and looped rapidly forward. We kept a sharp lookout and removed them from our feet to bottles before we became anemic.

Most wonderful of all were the giant hornbills. These are the birds which are famous for their peculiar nesting habits. The male seals the female up inside a hollow tree with mud. While his mate is brooding and rearing young he feeds her through a narrow aperture. Thus he protects his family from snakes and other predatory animals. When I first heard a hornbill, I thought a railway train was coming. The swish of the great wings sounds much like a freight laboring up a long hill.

Siam is wonderful and pleasant. The people are cheerful and friendly. Tropical nature is at its best. In general the country is healthful. There are always such diseases as cholera, plague, malaria and dysentery, but with ordinary care a traveler is in little danger. Go to Siam!

HOW RATS TRANSPORT EGGS

THE RAT-EGG-WAGON STORY TRACED BACK TO 1291 A. D.

By Dr. E. W. GUDGER

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY

Introduction

In another article recently published,[1] I have given from old natural history books some fabulous stories of how various quadrupeds are used as animated carts in the transport of various materials. That paper (and this also) had its inciting cause in the faulty recollection of a lecture delivered during my student days at the Johns Hopkins University by Professor W. K. Brooks on Conrad Gesner, one of the earliest and greatest of the old natural historians. My recollection was that he told us that Gesner described rats as transporting eggs in this fashion—one rat with his four paws grasps an egg to his belly, the others roll him on his back, grasp his tail and drag him away. What Gesner did allege was that the Alpine mouse or marmot thus hauls hay, as described in my article noted.

In the course of years of checking up all sorts of bibliographies and the tables of contents of thousands of scientific journals, for titles for my card catalogue continuing the "Bibliography of Fishes," and in the course of an omnivorous reading of natural history books, I have noted a thousand and one titles of all kinds of interesting natural and sometimes unnatural history lore. Incited thereto by my (erroneous) recollection of Professor Brooks's account of the rats and the eggs, I have noted as they came to me accounts of how rats transport food materials, especially eggs. These methods are of two different kinds, and the accounts will be presented accordingly. There is no attempt to cover the literature exhaustively. I have simply noted what has come to me easily.

Rats are most ingenious creatures. Their brains have been sharpened by thousands of years of endeavor to outwit their enemies. These in nature are probably the smaller carnivores, weasels, etc.; but as semi-domesticated animals they chiefly have to fear cats, dogs and men. Living in and around the habitations of man, they have learned most skilfully how to despoil him of his food. Some of these ingenious ways of securing this food almost bear the marks of reasoning. Two of these ways will now be set forth.

As pointed out by M. A. C. Hinton, in his "Rats and Mice as Enemies of Man,"[2] rats are very fond of eggs and they show great cleverness in stealing them from containers and in carrying them considerable distances and over many obstacles. They will despoil a hen's nest and even steal the eggs from under a sitting hen. Generally these are eaten on the spot, but frequently the rats are desirous of carrying them away. Unlike birds which thrust the beak into an egg and so transport it, rats find eggs, because of their weight, shape and brittle shells enclosing semi-liquid contents, very difficult objects to handle. However, they are known to transport them without breaking the shell or even leaving a mark on it. How they are alleged to solve the problem will now be set out.

How Rats Carry Eggs

Saving for the final section accounts of rats serving as egg-wagons, those allegations that rats *carry* eggs upstairs and

[1] E. W. Gudger, Scientific Monthly, 40: 153–157, February, 1935.

[2] British Museum Handbook, Economic Series, No. 8, 1918.

down and on the level will now be presented.

Transport on the Level.—This method of transport will be considered first, since it seems to be the easiest mode.

One would think that the easiest way for rats to transport eggs would be to roll them along on the floor or on the ground. However, there is the handicap that it is impossible for them to roll a conical egg in a given direction. But there are two published accounts alleging that they do so. This is stated as a method by James Rodwell in his interesting book, "The Rat: Its History and Destructive Character" (London, 1858, Chapter XI), but he gives no details. However, one interesting account is given by C. J. Cornish in his "Animals at Work and Play" (London, 1896, p. 271), where he quotes A. Trevor-Battye that he had seen rats roll eggs by applying their chests to them. Cornish speaks of this well-known author as an acute student of the rat, but I have been unable to locate any papers on this animal by him.

The earliest account, which I have found, of carrying on the level is also in Rodwell's book. A rat was discovered in a hen-roost struggling with an egg, but so intently that it did not notice the observers. "Its principal difficulty seemed to be in balancing the egg; this it did by stretching out one of its forelegs underneath the egg, and steadying it above with its cheek. When thus secured, it hopped very steadily and cautiously upon three legs; thus looking in its action more like a young rabbit than a rat." When the rat neared its hole, the man gave chase and the rat to escape let go the egg.

The next instance of a like manner of transport on the level is excerpted from Tom Speedy's book, "Sport in the Highlands and Lowlands of Scotland" (London, 1886, p. 373). He states his personal observation as follows:

> Going hurriedly into a stable where hens were in the habit of dropping their eggs, we witnessed a huge rat bearing an egg along the manger towards its hole at the end. It hugged it with one of its fore feet, holding it against its breast, and in this manner was travelling [on three legs] along the outer beam of the manger. [On our] Making a rush towards the stall, it dropped the egg; but falling on straw it was not broken.

Before leaving this section, Ernest Menault's "The Intelligence of Animals" (English version, New York, 1870, p. 212) may be quoted as to the ingenuity of the rat. "On another occasion the rats formed a line, passing the egg along from one to another," as men pass buckets of water in fighting fires. No reference is given, hence this account can not be checked up.

Such a passing from hand to hand is shown in a fanciful picture (wholly the conception of the artist's imagination) in J. H. Collins's "The Ways of a Rat."[3] Here a rat, standing in a bowl full of eggs, picks up an egg in its paws and tosses it to a rat on the table. This one, holding it in its paws, passes it over to the next in line, and so on.

Transport Downstairs.—The first account of this kind of egg-carrying is from Rodwell's book. It seems that some especially fine eggs in a pastry cook's shop had disappeared and all the help were under suspicion. Watch was kept and here is what was said to have been found. Two rats, one large (male?) and one small (female?) were the discovered culprits. When first seen they were both on one step, about half-way down the stairs. What then took place is described as follows:

> When the big rat descended to the step beneath, he then stood on his hind legs, with his arms and head resting on the step above, till the other rat rolled the egg towards him: then putting his arms tightly around it, he lifted it carefully down onto the step where he was

[3] *Saturday Evening Post*, p. 36, August 1, 1925.

—Photograph by courtesy of the Pierpont Morgan Library

FIG. 1. THE EARLIEST KNOWN FIGURE (1291 A. D.) OF THE RAT-EGG-WAGON TRANSPORT

From a Persian MS. in the Pierpont Morgan Library, the "*Manafi al-Hayawan* or Description of Animals" by Ibn Bakhtishu.

standing and there held it until she came down and took charge of it, while he descended a step lower. Thus they passed from step to step till they were fairly at the bottom.

A most extraordinary method of downward transport, which he denominates "A Living Egg Chute," is described by J. H. Collins in the article previously referred to. This has been published before, but I have been unable to locate the book. It seems that there had been great loss of eggs (20 or 30 dozen eggs of a night) by rats which infested a storage warehouse, so a platform 8 feet high was built with legs of smooth iron pipe, and on this platform the eggs were stored. The eggs continued to disappear, so an observer was posted. He reported that the rats climbed on to a gas meter, which projected out from the wall at a height of 4 to 5 feet above the level of the table, which stood "8 to 10 feet off horizontally" from the wall.

From the gas meter, the rats are alleged to have leaped on to the table. If the edge of the table was 10 feet from the wall, this leap would have been about 11 feet (as a simple calculation shows). This is a long leap for an animal not built for such activities. But the observer reported that they reached the platform, and their next actions are described as follows:

When they had gained the platform, these rats formed a chain to the floor, forelegs linked in hind legs [like the bridge alleged to be formed by monkeys over streams in South America]. It was a chain long enough to extend in an easy hollow curve [?] to a point on the floor some distance [?] from the platform, and the last rat in the line lay on his back. When this living egg chute was in place—and the animals worked as though they were performing an acrobatic act previously planned and rehearsed—things began to happen to those eggs. One by one they were lifted [?] from the crate, dropped [?] to animals on the platform, passed safely down the rat chain [in which all paws were occupied in holding fast] and away into the darkness of various rat holes.

This is a dandy story, which reminds me of a pungent criticism of a great public building—"Gorgeous in its ensemble, but faulty in its details." To be explained are an 11-foot jump out and away with a 4 to 5 foot drop onto a platform; the lifting of eggs out of a crate presumably 6 or 8 inches deep; the method of formation of this living chain; the tremendous grip on the edge of the platform exerted by the paws of the topmost rat necessary to support a 9- or 10-foot ("an easy curve") living rope of rats; the passing of 20 or 30 dozen eggs down this "living chute" of rats, each of whom was desperately holding on to the rat above with one set of paws, and onto the one below with the other set; and finally the method of dissolution of the living chain with safety to its component rats. This story is a work of art and imagination, but still it leaves too much to my feeble powers.

Transport Upstairs.—This is certainly more difficult than lowering eggs downstairs (save by the method just queried). There is but one account to be given. It is also from Rodwell, who quotes from the *Quarterly Review* (no date given and hence no possibility of verification) that rats carry eggs from the bottom to the top of the house by lifting them from stair to stair. The manner is described as follows:

The male [?] rat stands upon his head [?], and lifts up the eggs with his hind [?] legs, when the female takes it in her forepaws and secures it till he ascends a step higher; and so they pass from stair to stair till they reach the top.

The position of the rat seems absurd. Possibly the account is intended for a hoax. If it is intended to be taken seriously, then the describer surely got his rat turned end for end.

Ernest Renault, in the work quoted above, speaks in a general way of the upstairs movement, saying that with mouth and paws one rat would raise the egg up until the other could receive it. Unfortunately, he gives neither details nor figure.

Rats as Egg Wagons

We now are come to those accounts or allegations which constitute the grand finale. These will be taken up chronologically.

The rat-wagon method of transport is an old story whose origin goes far back into the dim past. Dr. H. H. Donaldson, of the Wistar Institute of Anatomy and Biology, Philadelphia, Pa., has for 25 years been collecting notes on the behavior of rats. Appealed to for help, when I began the pursuit of this particular hobby, Dr. Donaldson wrote me that he had seen in an old Persian manuscript in the Pierpont Morgan Library of New York a picture illustrating this story. Application to Miss Belle da Costa Greene, director of this library, brought an immediate response in the threefold form of a photograph of the page in question, a translation of the part relating to the rats and a description of the manuscript. It is a pleasure to make acknowledgment of this courtesy, which is uniformly extended to students by the Morgan Library.

Fig. 1 is a reproduction of the photograph, the earliest known illustration of this old story. The text speaks of the

FIG. 2. THE RAT-EGG-WAGON AS FIGURED BY J. B. OUDRY

THE RATS ARE HAULING AN EGG TO GET IT AWAY FROM THE FOX LURKING IN THE BACKGROUND. THE MOTIVE-POWER RAT IS PULLING OUT OF LINE WITH HIS FELLOW AND IS AT A DISADVANTAGE. —FROM LA FONTAINE'S FABLES, PARIS, 1759.

great cunning of the mouse [rat?] and the many tricks which it practises, and with regard to the figure says, in the translation by Abraham Yohannan, that:

> They have an interesting method of carrying away an egg; one of them lies down on his back and holds the egg with his hands and legs upon his stomach, another one takes hold of his tail and drags him towards their hole.

The painting is somewhat blurred, but the egg held on his stomach by the paws of the first rat is plain. The second rat has the tail of the first well up toward the root fast in its jaws and is pulling the first rat backward toward their hole, the opening of which is just behind the left hind foot of the puller.

This manuscript is thus characterized by Mr. M. S. Dimand, of the Metropolitan Museum of Art, New York City —"The earliest known manuscript of the Mongol period is the Persian copy of Ibn Bakhtishu's *Manafi al-Hayawan* or Description of Animals . . . [in] The Pierpont Morgan Library." The copier states that the manuscript "was finished with fortune and happiness in the city of Maragha [North Persia] on the eleventh of . . . 690." The name of the month is gone, but 690 A. H. corresponds exactly to 1291 A. D. and this may be assigned as the date of this interesting miniature.

This is the earliest known figure and account of the rat-egg-wagon story—644 years old. One wonders who old Ibn Bakhtishu was and where he got his story. Was it the outcome of his own observation or did he copy from some predecessor? Surely the imagination has free play here.

If the story of the rats and the egg was widely known in the East, one questions at once as to how it got into western Europe. Could it have been through the Arabs and Moors? This is conjecture only.

So far as I have found, none of the old worthies quoted in my earlier paper ("Animal Carts: How Marmots, Badgers and Beavers Serve as Sleds or Wagons") describe the rat-transport of eggs by the wagon-method. Knowing their fondness for such "tall tales," their absence from the old natural history books would seem to argue that this story was not known in those days. My error as to Gesner has already been noted. The history of the rat-egg-wagon story is then blank until one comes to the last quarter of the seventeenth century.

The next, and indeed the first modern rendition of our story known to me, is from the pen of Jean de la Fontaine. It is in his "Les Deux Rats, le Renard, et l'Oeuf" (No. CLXXXIX of his "Fables") which was dedicated to his patroness, Madame de la Sablière. This was first published in 1678.

The first figure (known to me) drawn to illustrate La Fontaine's account is from the pencil of J. B. Oudry. It forms the first plate of Tome IV of "Fables Choisies" published in Paris in 1759. It is reproduced herein as Fig. 2.

In none of the other French editions, examined in the New York Public Library, is there an illustration of this fable until one comes to the "Fables de la Fontaine avec les Dessins de Gustave Doré" (Paris, 1867, T. II, p. 195). Doré has two interesting drawings, duplicates save for size and intensity of color. The smaller and lighter colored is reproduced herein as Fig. 3.

For a charming translation of that part of the fable illustrated in these figures, I am indebted to an English version of the "Fables" published by Cassell, Petter and Galpin (London, 1878, p. 615). This reads as follows:

> Two Rats, seeking something to eat, found an Egg,
> . . . . . .
> Full of appetite, nimbly they sat down to eat

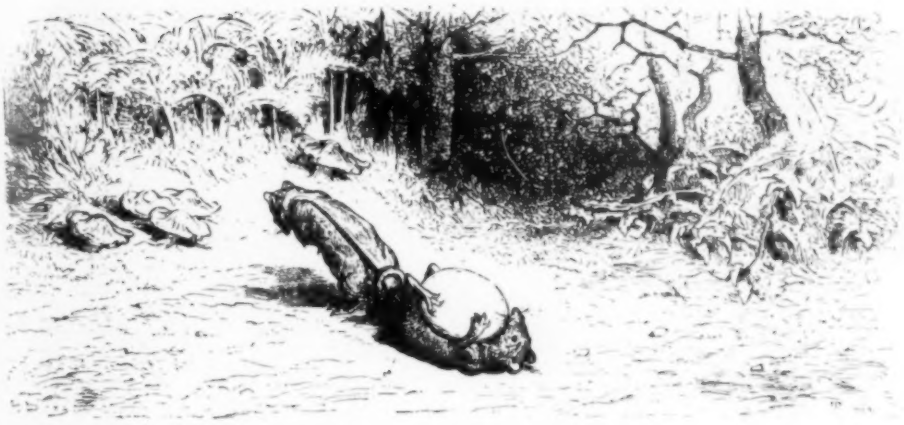


FIG. 3. GUSTAVE DORE'S DRAWING OF THE RAT-EGG-TRANSPORT

THE MOTIVE-POWER RAT HAS THE TAIL OF THE EGG-WAGON RAT OVER HIS SHOULDER AS A MAN WOULD HAVE A ROPE TO DRAG A HEAVY OBJECT. NOTE THAT THIS RAT HAS WOUND HIS TAIL AROUND THE BASE OF THE TAIL OF THE OTHER TO GIVE HIM A BETTER PURCHASE.
—FROM LA FONTAINE'S FABLES, LONDON, 1878.

And soon from the shell would have drawn out the meat
When a Fox in the distance appeared to molest them,
And a question arose, which most greatly distressed them,
No other, as you may suppose, but the way
The Egg from Sir Reynard's keen snout to convey,
To drag it behind them, or shove it before,
Were the plans tried in turn, but were all tried in vain
When at length the old mother of arts[4] made it plain
That if one on his back held the egg in his paw,
The other from danger could readily draw.
The plan was successful, in spite of some jolting;
And we leave the two sages their pleasant meal bolting.

These two charming figures deserve some comment. Each is of course the artist's concept of the author's account. In Fig. 2, Oudry shows the egg-carrier with his head and neck lifted clear of the ground holding tightly onto the egg. This is a very strained position, as the look on the rat's face shows. The draft-animal has laid hold of the other's tail with its paws and stands to one side as he drags his fellow along. This method is surely faulty, as may be seen on comparing Doré's figure (No. 3 herein). Here the carrier has his neck and the back of his head on the ground and is contentedly "leaving it to George." "George" has grasped his friend's tail with both paws, has slung this over his left shoulder and is pulling away for dear life. He has taken the very pose that a man would take in dragging a heavy load on the ground. The artist has put in another interesting detail—the motive-power rat has coiled his tail tightly around the base of the tail of his friend to give him a stronger hold on the egg-wagon.

So far as the data in my hands give us information, there is a long break in time after La Fontaine in 1678 till we come to the next publication of this story in 1803. There must have been other publications, but I have chanced on none. Fortunately my friend, Professor F. E. Clark, of the University of West Virginia, knowing my liking for what he

[4] Necessity.

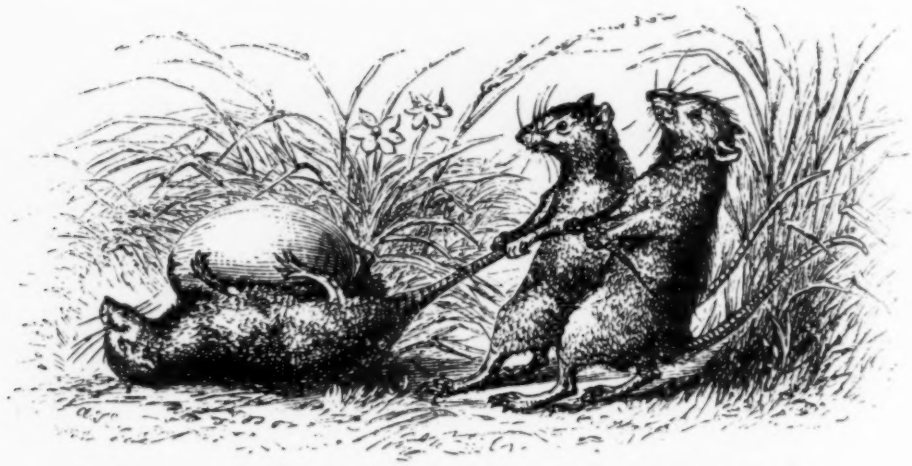


FIG. 4. TWO RATS ARE DRAGGING THEIR LADEN FELLOW

NOTE THE HAPPY EXPRESSION ON THE COUNTENANCE OF THE SECOND MOTIVE-POWER RAT AND THE COCKY ATTITUDE OF THE TAILS OF BOTH.—FROM ST. JOHN, 1878.

designates as "unnatural history," has sent me a copy of "The Hive," a curious old newspaper issued at Lancaster, Pennsylvania. In Vol. I, p. 195, 1803, under the heading "Sagacity of Rats," are found some interesting stories. It seems that in Amsterdam, a certain householder kept fowls. One of his hens would cackle, but the nest was empty—no egg, no shell, no anything. Watch was kept. An egg was laid

> . . . but no sooner was she off her nest, than three rats made their appearance; one of them immediately laid himself on his back, while the others rolled the egg upon his belly, which he clasped between his legs, and held it very firm; the other two then laid hold of his tail and gently dragged him out of sight.

The next modern account which I have found bears the comparatively late date of 1854. In the *Zoologist* of that year (Vol. 12, p. 4285) A. C. Smith says that a "Mr. Bury assures us that [to transport it] the rat will grasp a hen's egg with all four paws, and then turned on its back will suffer itself to be thus with its prey dragged away by its tail to a place of security convenient for dining."

Next Rodwell (1865), who has been quoted above, gives without credence the following account emanating from Argyleshire, Scotland. Four rats were alleged to have rolled an egg away from a pile of such: then "One of the party, falling on his side, firmly embraced it with his legs; then being turned on his back, the rest yoked themselves to the burden, two in front [pulling] and one behind [pushing], and by this living vehicle they safely conveyed their booty to the hole."

This variant of the now familiar story introduces a new means of locomotion—propulsion by one rat in the rear.

Rodwell quotes another account, which he says was plainly intended as a "big story." One rat embraced the egg as above and the other dragged her along by the tail in conventional fashion until they came to an obstruction—a beam. Then was introduced an action which is inserted here in the light of what is to follow later. One rat climbed the obstruction and then dropped his tail to the other who grasped it tightly in her mouth (her paws being occupied in holding the egg). He sat on the beam

"and pulled up his mate, who held tight to his tail; then let her gently down on the other side." Then the wagon-transport was resumed.

Next comes one Henry Moses with a note, "Rats Carrying off Hen's Eggs," in the *Zoologist* (1865, Vol. 23, p. 9431). A rector of a parish in Westmoreland (England) reported to him that, having lost many eggs, he set a watch for the thief. On hearing a hen cackle, he observed two rats which came out of a hole in the hen-house and proceeded to the nest. There they rolled out an egg, one secured it in the fashion described and the other dragged this rat and the egg away.

Charles St. John, in his charming book, "Sketches of the Wild Sports and Natural History of the Highlands" (London, 1878, and 1893, chap. VII), comments upon the fact that rats transport eggs for some distances without breaking them. He asks how this is done, and then without a word of explanation, he closes his chapter with the annexed figure (Fig. 4 herein) as a tail-piece. Here is introduced a variant in that two rats furnish the motive power. They grasp their friend's tail in both forepaws and facing the animated cart back away from the scene dragging the other rat and the tightly held egg.

Next is an eye-witness account communicated to me personally in 1932 by Dr. W. E. Aughinbaugh, of the Explorers' Club, New York. At Caracas, Venezuela, about 1906, he was awakened one night and, looking out into the patio of his house, saw under a brilliant tropical moon a rat lying on its back and holding an egg between its paws. The white egg was plainly visible in the moonlight, and one rat was either pulling or pushing the other down a slight incline. His native servants told him that one rat always pulled the other by the tail, and that this performance was "costumbre del pais"—the custom of the country.

The next two accounts are from present day eye-witnesses. In May, 1932, I published in the *Journal of Mammalogy* an appeal for references to accounts of rats moving eggs and for first-hand information thereon. A letter came from Dr. Henry H. Donaldson, saying that among his data were two first-hand accounts. These he later sent me with permission to have them copied for use.

The first was communicated by Miss Mollie E. En Holm. She writes that, in 1897 or 1898, she was living in Pocantico Hills, Westchester County, New York. The winter's stock of potatoes kept dwindling, so watch was kept and the following observation made. "I saw a rat dragging another by the tail, which latter was on its back clasping tightly in its paws a large sized potato." Here the object is not an egg with a fragile shell enclosing semi-liquid contents, but a solid potato. One would have expected the rats to roll it along, or to sink their teeth in it and drag it along. Possibly, however, it was too large and heavy.

The other and final account in this article was communicated to Dr. Donaldson by Mr. Arch. E. Scott. The events occurred in September, 1929, at Stony Point, on the Hudson River. The continual disappearance of eggs and the frequent appearance of broken shells around the door of the hen-house (generally left open) led to the strong suspicion that the rats were the culprits. So Scott kept watch in the hen-house on a bright moonlight night. The door was closed and the wooden floor had but one hole in it—with claw marks on it. Scott settled himself on the overhead beams to watch. The disturbed chickens soon calmed down and all was quiet. The bright moon shining through the window illuminated the boxes in which were the nests and a 6-foot width of floor in front of the nest-boxes. As bait a very white egg was put in the middle box, which was about 7 inches deep. For nearly an

hour nothing happened and then—but Mr. Scott will tell the story:

> Did not hear rats arrive but saw one on floor and one going along the back of the boxes. The one on the floor jumped up, ran along edge of boxes and stopped at the egg. The other came back and both went around the edge of the box and slipped into the nest. Here they were lost to sight. Scuffling heard. One rat came back to edge of box. Leaned over gingerly and straightened up slowly. He (rat A) had the tail of the other rat (rat B) crosswise in his mouth. Lifted with skill till almost upright, and lowered rat B, which was clutching the egg to his belly, to the floor. The details of the operation could not be followed. There was no squeaking or other noise. Rat A jumped down, took tail of rat B crosswise in his mouth and dragged rat B across the six feet of illuminated space. In doing this, rat A walked forward and had the tail of rat B over his shoulder and the body of rat B close beside him.
>
> Rat B lying on his back was being pulled against the lie of his hair and was humped more or less into a ball. They moved towards the door sill but could not be seen after passing out of the moonlight. After they had gone a little way in darkness, the dragging noise stopped. Then came a sound like a gurgling squash. No scampering, but the rats came back and stopped motionless at the other corner of the nest-box, apparently thinking over the situation. Then they ran back to their hole in the floor.

Since the rats did not return, Scott climbed down. There was the broken egg with no tooth marks on the shell. He could not determine whether any of the contents had been eaten. When the occurrence was related to the farmer, he stated that rats transported apples and the like vegetable objects by setting their teeth in them and dragging or pushing. In this account the manner of lifting the egg-embracing rat out of the box containing the nest recalls the method of lifting the egg-holder over the beam recounted above.

It is interesting to note, what many readers have surely already had in mind, but what Mr. Scott only has called attention to, the fact that all accounts and figures have the rat-wagon pulled against the lie of the hair. This of course adds greatly to the friction. However, the tail offers a fine holding-on piece, much better than ears and snout.

As to the rat-egg-transport—"Believe It or Not." The alleged facts are quoted with meticulous care. With reference to his two correspondents Dr. Donaldson writes me that "With both my informants [Mr. Scott was a student at the University of Pennsylvania in 1929] I had considerable personal conversation, and I feel that their statements can be trusted, so that their observations may be used without reservations." And with them Dr. Aughinbaugh's personal observation agrees closely.

For myself I can only repeat Professor W. K. Brooks's comment when I reported before the seminar in zoology at the Johns Hopkins University in 1904 on A. C. Oudeman's book, "The Great Sea Serpent: an Historical and Critical Treatise." When asked what he thought about the existence of such an animal, he answered that "It is not safe to say that a thing does not exist in nature merely because neither you nor any other scientific man has as yet seen it." That is my attitude, and waiting for photographic evidence of a rat-egg-transport, I shall keep an open mind. "There are more things in heaven and earth than are dreamt of in our philosophy."

WILD LIFE OF THE FOREST CARPET

By ARTHUR PAUL JACOT

APPALACHIAN FOREST EXPERIMENT STATION, ASHEVILLE, N. C.

DEER, jumping mice and the oven-bird are denizens of the forest floor by virtue of using it as their substratum, but there is also a host of curious animals which use the forest floor, especially the litter of dead leaves, twigs, branches and fruit parts, as their walls, ceiling and sub-basements. Looked at from the eye level of the cockroach, this litter layer becomes a several-story edifice of enormous extent. The various floors are separated by twigs, midribs, petioles, fruit husks, samaras, skulls, elytra and feces. The lower one descends, the more compact is the structure. The leaves become more fragmentary, the feces of worms, which have come up from the soil, of caterpillars which live in the trees and of the inhabitants themselves, as well as grains of sand brought up by the worms and a heterogeneous assortment of ant and beetle skulls and wing covers, become more abundant. This complex is rendered more intricate by the growth of minute fungus moulds which feed upon the dead leaves and other organic refuse, weaving it all into a compact mat by their myriad white hyphae. Thus is the woof woven into the warp of the woodland rug. And what of the moths and carpet beetles?

It is a matter of common observation that deer are more sparse than rabbits or white-footed mice. This is not due to their using different heights of trees for cover, but in part to the ratio between stomach capacity and available food supply and in part to the speed with which their respective enemies are able to quarter their habitat. It may not be generally known that in a state of nature not exploited by the white man, bears and wolves are less numerous than deer or that foxes are less numerous than rabbits. This is a result of availability of food supply. The territory of a grizzly is forty square miles, the territory of a red squirrel is five acres of woodland, of a vole a thousand square feet. In the forest carpet the same ratios obtain. There are forms of life corresponding to deer, rabbits and mice as well as bears, wolves, weasels, lizards, snakes and hawks.

In a more detailed review of these unfamiliar wild animals it will simplify matters if we restrict ourselves to a piece of carpet one square foot in extent and free from moss-plants and lichens. Naturally, such a restricted area will not, except by the merest chance, include such scattered and wide-ranging forms as deer (crickets and roaches), bears (carabid beetles), wolves (rove beetles), turtles (scarabid or dung beetles) and birds (various flies or bees nesting in the soil). Even the larger land shells will be overshot. This is another way of saying that by restricting our examination to one square foot we correspondingly and automatically restrict the animals we study to species measuring less than a quarter of an inch in length. Were we to take a square yard or meter as the unit, the animals would be increased in size to a length of one inch. If the unit were a square inch the fauna would dwindle in size to animals of a tenth of a millimeter or less. Similarly, having chosen the square foot, the lower size limit of the animals will be two or three tenths of a millimeter. A final observation is necessary. This size ratio is not really one of length but of bulk, so that an attenuated form like a threadworm (nematode), centipede or snake will fall in a size group lower than its length alone would indicate. Thus, although

we may exclude nematodes two to three tenths millimeters in length, we will include millipedes and centipedes half to one inch in length. The reason for this ratio of size of animal to size of unit area is that every non-parthenogenetic female of each free-living animal must be near enough to a mate to be able to reach him within her lifetime. As soon as the individuals of a species become so sparsely distributed that the females can not find mates (barring parthenogenetic species), reproduction of that species ceases. Thus volant animals can afford to be much more thinly scattered in the leaf litter than are non-volant animals of the same size. For instance, there is one individual of the minute feather-winged beetle (Ptiliidae) to every ten thousand mites of the same size. There is only one individual of the smallest Pselaphid beetle to every thousand springtails of the same size. In brief, springtails and mites must be much more numerous per unit area than volant insects in order to meet and mate. An exception is found in the land snails.

The total visible population of the square foot is made up entirely of arthropods, with a thin sprinkling of minute land snails. These animals, it will be noted, all belong to groups with a hard or dense outer coat-of-mail. Depending upon the depth or thickness of the carpet, the total number will vary from two thousand to twelve thousand "souls." The marvel is how can an average of nine thousand individuals large enough to be visible without a lens live in any and every square foot of forest litter without walking all over each other. It is a veritable greater New York, Paris or London. The possibility is largely due to two factors: availability and variety of food supply, and the use of skyscrapers which, due to a sacrifice of light, are not of the "built-back" type but continuous and bridged, over vast areas.

In a community one might ascribe importance, (1) to one individual, as in an anthropoid empire, (2) to the species having the greatest number of individuals, as pines in a pine wood, or (3) to a virulent species, as the chestnut blight fungus in a Connecticut woodland. Possibly the most important animal of the great plains in precolumbian days was the bison. Now it is *Homo sapiens*, white. In certain parts of Iceland and at certain times of the year the dominant species is the mosquito. Thus size alone is not an indicator of dominance—as in plant ecology. In animal ecology, on purely *a priori* grounds, numbers have been used as a pretext for labeling species as dominant or subdominant, seasonally or otherwise. That numbers affect a community is unquestioned, even if their only contribution through the ages is guano. Before any real evaluation can be made of any one species of a community, its function in that community must be determined. A species which shelters in a community for a limited time is not a dominant or even a sub-dominant, especially if dormant while there. In colonial days the passenger pigeon would devastate a piece of woodland chosen for its rookery by sheer weight of numbers. Nevertheless, it was not a dominant form of that woodland any more than a cyclone would be. As a lead, however, one may begin a sociological study by determining the function of the most numerous species.

In the case of the forest carpet there is one millipede, proturan, thrip or plant-eating insect larva for every thirty springtails or every fifty vegetarian[1] mites. In the case of the predators there is one centipede, ant, spider, pseudoscorpion, beetle or predaceous bug for every ten predaceous mites. Thus one can say that the mites and springtails are numerically the dominant groups. Whereas all other groups are numbered by units or tens, these two are numbered

[1] The term vegetarian throughout this paper includes saprophytic species.

by the hundreds (predaceous) and thousands (vegetarian). Among the springtails, there is always one or a few species in great abundance, while the other species are numbered by units and tens. The same is true among the mites.

Biologists explain this minority in the number of individuals of a species as due to their being out of their normal habitat, relics, of low fecundity or reproductive ability or as strongly held in check. In such cases the species can never hope to attain importance in that habitat or under that set of conditions. No matter how low is the reproductive ability it must always be enough to assure meeting of individuals for purposes of mating. Apparent rarity is due to ignorance, on the part of man, as to the exact habitat or niche of that species. Cyclic or seasonal rarity is not an average condition.

Out of a total population of one hundred and fifty species of jointed animals that may be found in any one square foot of woodland floor, at most ten only can be dominant or sub-dominant in numbers. The evaluation of the remainder is problematical. It is certain, however, that out of one hundred species of vegetarians (and saprophytes) in an area of such restricted choice of foods (dead leaves, dead wood, fungi, dead bodies, feces) there must be a great deal of duplication of feeding habits. Many unrelated species must feed at the same table. This is not specialization and diversity, but parallelism of habits. Sameness of feeding habits in such a restricted area is possible only because of the ever-renewed leaf and twig manna.

The food supply consists of dead leaves (grain), dead wood (potatoes, carrots and beets), fruit parts, bud scales and flower parts (beans, lentils, cauliflowers, tomatoes, spinach), pollen grains by the myriad, spores of mosses and fungi (fruits), caterpillar feces (cheeses), droppings of many animals (the entire sewage system of such an establishment) and the dead bodies of the community. Although there are no merchants, as the food is eaten in situ, there are undertakers and the night-soil brigade, even more beautifully developed than that of China. The work of one cast or guild is not done by the other. For instance, mites of the genus Odontocepheus are exclusively feeders on decaying, soft, punky wood. Whether they eat the wood for the nourishment in the wood (which is really decomposed by the intestinal biota) or for the fungal hyphae permeating the wood is not known. But it is certain that they push their subways for mite-mile after mite-mile along a dead branch or through an old log. Such species are the termites of the northern woods. They do not, however, frequent seasoned or dry wood but wait until fungi have rendered such wood soft and punky. They are never found outside of decaying wood, except by accident, or in moving from an exhausted supply to a fresh, or to find a mate after their own kind. The larvae of some deltoid moths feed exclusively on dead oak leaves. Certain species of springtails eat only spores. Certain mites are just as addicted to the use of predigested tidbits as is the holy beetle of ancient Egypt. The undertakers are the world's most practical—they eat the corpses. Thus there is no cemetery. The sewage disposers follow suit. Each after its own kind, one more particular than the other—with the exception of certain general feeders.

The food of most of the non-predaceous is not definitely known. Most of them have been regarded as destroyers of the leaf litter which would accumulate to the extent of several inches per annum if not destroyed. Such an accumulation would soon sour the land and kill its vegetation. These animals keep it full of holes, galleries and corridors, allowing water and air to circulate. They also reduce it to less highly organized matter, thus hastening soil fertility. Under certain conditions the predators

become too numerous and hold in too great check the litter reducers. Under other conditions the fungus eaters become too numerous and inhibit the development of the cellulose-decomposing fungi, so that the litter does not properly decompose. Under still other conditions the fungus eaters are so reduced in numbers that the fungus develops a dense, hard mat which covers the soil as a layer of papier-maché. All these conditions can be remedied to produce a soft black mull or a rapidly reducing duff. For this reason the artificial control and culture of the forest floor fauna is of direct economic importance, especially to forestry.

On the other side of the fence is arrayed the army of predaceous and parasitic species which average one to every nine herbivores. Millipedes are vegetarians, centipedes or predators. The minute Staphylinid and Pselaphid beetles, which are quite insignificant in numbers, feed upon springtails and possibly mites. Of mites there are at least three common predaceous groups. In fact, I find that of all the mites of any square foot one sixth are predaceous. Many of these predaceous mites feed upon springtails and possibly nematodes, as well as on their milder relations. Minute parasitic wasps are occasionally encountered. A group of mites more or less parasitic on larger mites and insects are abundant. And here also lies in wait the jigger.

In order to protect themselves from this horde of predaceous species, the springtails have developed the caudal springboard which, when released, catapults them through space. As such a mode of progression is useless inside a tenement, the inhabitants of the low-ceilinged lower levels are without or with rudimentary springboards, while the habitués of the roof garden have them so well developed as to enable them to clear an entire level (leaf) at one spring. Exceptions occur, as elsewhere in life. A second mode of protection or adaptation is size and shape. Dwellers near the soil are smaller and depressed and can slip through much smaller doorways and down more low-hung runways than their pursuers. Per contra, the sky gazers are considerably larger and have compressed bodies, often garnished with a heavy suit of their own hair. Another protective device particularly developed in some of the mites is B. O.

The mites, having set forth in Precambrian time to reduce the length of their bodies, could not break their tradition by the development of caudal appurtenances. Instead, the largest group, like the beetles, developed a dense coat-of-mail. Having pushed their tradition of reduction of body length so far as to have lost almost every vestige of body segmentation, their coat-of-mail lacks transverse joints. Like the turtle, the entire body is enclosed in a dorsal and a ventral carapace but so constructed that the lower fits under the rim of the upper. Thus clipped in, they are quite impervious to sucking probes. Their only enemies are therefore internal, including fungi, and animals that can swallow them whole. To protect themselves from such much larger animals, snuggling into crannies, fissures and pores has become their habit and to such an extent that it is difficult to find them in their natural habitat even with a hand lens. These mites outnumber all other animals of their habitat two to one, because of their extremely slow rate of locomotion. In fact, if a he-man-mite were separated from a lady-mite by a log one foot in diameter it would take him an hour to reach her if he could travel in a straight line up over the log and had no floor leaves among which to meander. Springtails, with two legs less and a much longer body, are ever so much more rapid walkers.

As a result of having to live generation after generation in the darkness of the sub-basements without electric lights

or phosphorescent organs, about three quarters of the population are eyeless. This condition obtains in all the herbivorous mites (five thousand) and two thirds of the springtails (two thousand). Other sense organs, however, are highly developed in some groups. Loss of eyes has been accompanied by loss of pigment, with the result that two thirds of the springtails of these lower layers are white, while a large proportion of the mites are of pale coloration to white. As one ascends, springtails with pigment become more numerous, so that on the roof-gardens (the loose leaves on top) the springtails have variegated colors and bizarre color patterns and are larger and much more vivacious. This enhanced and sprightly life with its colorful camouflage is necessitated by the momentary possibility of the alighting of aerial coursers such as predaceous flies, bees and beetles or the sudden whipping in of racers like the ground spiders, daddy-long-legs and other large carnivores. Then must every herbivore know the location of each scuttle, door and screen. Where the forest canopy is the least bit open this life is chiefly nocturnal. Why, then, such wealth of color? Perhaps to these animals with their compound eyes and eyes of various colors, *tous les chats ne sont pas gris*, and they are able to recognize patterns if not colors. Or perhaps they are more crepuscular than nocturnal.

One of the outstanding features of lower Manhattan is the diurnal human tide which ebbs and flows through the lower levels. The motion is chiefly lateral and governed by the chronometer. In the forest carpet the tide is as marked, but vertical and governed largely by the barometer, hygrometer and/or photometer. We do not know if the hordes are moved directly by changes in atmospheric pressure, but we do know that they occupy different horizons during different moisture conditions. Night, with its greater coolness and moisture, causes greater activity among the upper layers, daylight causes a descent. Advance of frost with its drying effect also brings on geotropism. For instance, the minute land snails, of which there are from three to twelve species, depending upon the type of woodland, take to the soil on the advent of frost or dryness. Other animals, often a particular species or genus in any one group, are quite resistant to drought, while others are very hygrotropic. Among the vegetarian mites, active species (as in Liacarus) are very sensitive, while slow species (as in Nothrus) are very resistant—which is as it should be, according to the law of survival. Of the five species of thrips common in leaf mould of the blue ridge region, one species is found chiefly and typically in the upper, drier layers; one is found chiefly in pine leaf mould, and the other three in the lower layers. These may have special feeding habits.

Like us, these animals, at least most of them, keep their eggs in cold storage. The region of their domain which is most constant in temperature (and humidity) is the soil. Hence the gravid dames descend to the soil layer to parturate their unborn young. As the laying season extends through the growing season, forest fires do not exterminate the fauna, though it leaves the newly hatched young with extremely little food and shelter.

So extensive a society is not without its characters. Don Quixote is here called the pseudoscorpion. Most of our pseudoscorpions reach a length of three millimeters. They are armed with two large pinchers on the front of the head and two huge, crablike nippers held out at the sides of the head. Thus they have a frontal battery unexcelled by any other denizen of the square foot. If touched they make a precipitous retreat running backward with great agility. I suspect they only chase what runs from them. If you see a hill slowly rise and

walk off on four pairs of stout, bowed legs you would understand that a species of the mite Camisia is making off with its load of accumulated trash, for, like some Reduviid bugs, Camisia has learned to blend itself to the landscape by carrying a part of its background on its back. When you see a crinkle-surfaced caterpillar feces move slowly off, you should appreciate the protective sculpturing and coloring attained by mites of the subfamily Carabodinae. The vender of palm fans (*Phyllotegeus palmicinctus*) carries its wares in concentric circles on its back. Cepheus, the vender of halberd heads, similarly displays its goods. The box turtles and armadillos are represented by the Phthiracarid mites, which draw their eight legs into the anterior end of their abdomen and then cover them up with their trench-helmet covered heads. The Galumninae have diverged from all other groups of the animal kingdom in that they have developed bilateral wings resembling apple petals behind which they enclose their legs. Short, squatty forms in blues, yellows and violets, which spring like frogs when touched, but ever so much further (for their size) are Sminthuroid springtails, while the other springtails are more like grasshoppers and crickets. Stiletto Pete (Bdella) in his ruddy skin darts here and there with his dagger held ever before him ready to strike and suck. Minute spiders, with their six to eight eyes, on a conning tower quarter the concourses for anything that moves. Scarface Al. (Gamasid mites) slinks about with a pair of hedge shears held ever before him ready to clip the flight of juicy springtails. Most formidable of all are the dragons (centipedes) whose long, sinuous, many-legged bodies flow in and out of the corridors, feeding on any moving object. The short ones (Lithobioid) run most rapidly, while the long ones with three times the number of legs (Geophiloid) run most slowly. Hawks (the minute parasitic bees) come darting down, stab an egg into their victim and are off so quickly the victim is all unaware of the Jekyll which will develop within him. And this is the life that any one of us covers with his two feet on any woodland floor.

SOME OLD BIZARRE MEDICAL REMEDIES

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Introduction

Since the day Pandora lifted the lid of the pestiferous box, methods and means of combating disease have rapidly accumulated. A few active remedies were stumbled upon in the course of time, but they were almost totally submerged by the great mass of their inert competitors, so that long before the Middle Ages the *materia medica* included almost everything under the sun. Some of the ingredients of Shakespeare's witches' cauldron were, as might therefore be supposed, not confined to the elixirs with which hobgoblins and their ilk tried to convert the golden hearts of the elect to dross but were allotted places in the apothecaries' shops among such things as centipedes, horse dander, mummy and scores of other things of equal rank. An apothecary indeed had to be a valiant man with no too squeamish stomach, for many a mess he had to prepare was, in truth, "so loathsome that one would expect to see the worst disease leave the body in haste to escape the contamination."

The basis of the therapeutic art in those dark ages was, of course, the medical system of Galen, bad in itself and much corrupted by an admixture of old wives' lore and other humbuggery. When the Arabian alchemy penetrated into Europe, there came with it a few good remedies which had been run across in the hunt for the philosopher's stone.

Most of the material of the present article will be found to be drawn from sources of the seventeenth century—a very active and familiar time of the world's and especially of England's history. It is the time of Shakespeare, Jonson, Charles II and Samuel Pepys, Robert Boyle, etc. It is the age, moreover, which saw the culmination and the beginning wane of the old medicine and indeed of the whole philosophy which had ruled the world for two millennia. In its early years Galileo with his home-made telescope made some remarkable discoveries. About the same time Dr. William Harvey demonstrated the circulation of the blood. But it took a great while for these and other enlightened empirics to make an impression on the rank and file of their reactionary associates. The attitude of the time is well illustrated by the fact that Harvey let twelve years pass before he dared publish his work for fear of ridicule. The universities were still citadels of conservatism. There one was informed that the elements were earth, air, fire and water, and perhaps a few others. In the medical classes one heard explained that disease was an inbalance of the humors or was due to an unpropitious conjugation of the planets.

But about the time of the Commonwealth and the beginning of the Restoration in England, fresh blood began to flow through the ancient cadaverous body of learning, and with the advent of the Royal Society and its purging influence some of the erstwhile prized treasures went to pot. Philosophy and mysticism gradually began to be replaced by investigation and experiment. In the medical field the study of anatomy took a great step forward. Therapeutics also began to advance, but being rather ponderous it moved more slowly, and the Galenic herbs and motley array of medieval drugs persisted far into the following centuries.

Charms and Incantations

Though improvement in general was slow, magic charms and incantations, at least, were falling into disrepute. They were still in popular usage, but the reputable members of the medical profession had ceased invoking the supernatural in their attempts to cure. But as these represent the healing art in the full strength of its pristine crudeness, it may be well to begin by citing a few of them.

In the famous "Compendium Medicinae" of Gilbertus Anglicus, written at the time of Richard the Lionhearted, and very popular for several centuries, the following sure cure for impotence is recommended:

> Let a man twenty years of age or more, before the third hour of the vigil of St. John the Baptist, pull up by the roots a specimen of consolida major [cumfrey] and another of consolida minor [heal-all] repeating thrice the *oratio dominica* [Lord's Prayer], let him speak to no one while either going or returning, say nothing whatever, but in deep silence let him extract the juice of the herbs and with this juice write on as many cards as may be required [*i.e.*, to use up the juice] the following charm:
>
> *Dixit dominus Crescite.†. Uthioth.†. Multiplicamini.†. Thackehay.†. et replete terram.†. amath.*

It was to be used as an amulet. The meaning of the words is, in so far as they have a meaning: "The Lord said, Be fruitful and multiply and replenish the earth." The parenthetical expressions, between the signs of the cross, have a Hebraic ring, but the author is able to make nothing of them. At any rate, to replenish the earth is a large order, though perhaps not excessively so, for the charm was very potent, which is seen from the fact that the author deems it necessary to warn against the dangers of satyriasis which might accompany it, and sets forth suitable precautions to forfend that occurrence.

The above is, of course, a translation from the Latin, in which most books of the time were written, but what follows is a quaint one from an English book of the fifteenth century. It is for epilepsy:

> Take xij candylls of ye length of ye chefe joynt of ye hande, and the xiij candyll as long as the iij of the sayd xij and gar synge [cause to be sung] on[e] messe of the holy ghost, and gar lyght [cause to be lighted] the sayd xij [xiij] candylls, and apun every candyll wryhte on[e] name and apon the large candill jhc,[1] and apun the ryght syd sante petur and apon ye lyeft syd sante paulle, and apun yelke [each] on[e] of ye oyer [other] candills sette a name of the xij apostylls, so that vj stand on the on[e] syd and vi apon toyer [the other] . . . and heyd [notice] whilk of the candills endure the longest, and to the same appostyll the seky [sick] body must woue to fast the evyn to brede and water while he levys.

This, perhaps, is not altogether bad advice, for epileptics who have attacks with especial frequency at night are often benefited by going to bed on a relatively empty stomach and one is not apt to gormandize on bread and water. For this same condition the previously quoted Gilbertus Anglicus recommends a concoction of ants' eggs, scorpion oil and lions' flesh. If this were made the principal article of diet it would be of the order of the low carbohydrate diet recently advocated for the same condition.

Amulets

Into a class similar to magic incantations belong amulets. They appear to have been used from time prehistoric, and they were very popular in medieval Europe. They consisted of dead men's teeth, animal bones, curiously shaped stones, gems, parts of plants, wrought objects, as the sacrament shillings (coins collected in churches on Easter Sunday), verses of holy writings, religious phrases and the like. The famous jingle, abracadabra, was one of these. Ordinarily it was just hung about the neck, but in

[1] jhc: Probably an attempt at translating into Latin characters the first three letters of the name Jesus in Greek, sometimes seen in modern church decoration thus: IHΣ. The latinized form is probably the source of the ribald expression, Jesus H. Christ.

urgent conditions best results were obtained by rolling the parchment into a bolus and swallowing it. The etymology of this bit of jargon is said to be from the initial letters of the phrase "Father, Son and Holy Ghost," in Hebrew (Ab, Ben, Ruach [H]Acadosh).

As has been already indicated, at the start of the seventeenth century things of this sort were well on their way to desuetude, at least among the more responsible members of the profession. Patients then, as now, desired something tangible, as pills, potions and plasters in return for their physicians' fees, and incantations became a rather poor source of income as the firmly entrenched superstitions of the Middle Ages began to loosen on their foundations. Though obsolescent, they were by no means obsolete, as the following amulet suggested by the learned Dr. Bates, "physician to two Kings of England and a Protector," attests. It is called "Turquis Infantum."

It is made of the male Peony-root and Henbane-root, fresh-gathered, cut into round pieces and bored thro' the middle and strung in order upon a Thread or String, which being wrapped in a fine Linnen or Lawn, are to be worn about the Neck in the time of breeding Teeth. They are said to facilitate the breeding of Teeth and to prevent Convulsions.

The recipe for this necklace came from Bates' "Dispensary." Dr. William Salmon, who revised and enlarged the book in 1694, comments as follows:

It is to be used as an Amulet, in which I believe there is no more Vertue for driving away Pains in the breeding of Teeth, than there is in the words being worn about the neck as a Pentacle. But for such as have Faith in the thing (and I know not but Faith may do the Work) they may put it about their Childrens Necks, and let them wear it as long as they are breeding their Teeth. If in this Time the Child should be cross and froward and peevish, with the anguish of its Teeth cutting, the Parent or Putter on thereof must wholly blame themselves (and not the Medicine) for that they were people of little Faith.

Discussing another such prescription from Bates, named "*Amuleta Pestilentialia*" (amulet for the plague), consisting of a few crushed drugs to be put into a little bag, Salmon very generously recommends the addition of a little mucilage to hold it together. "Paracelsus and others," he continues, "are of the Opinion, that there is a mighty Powr, Force and Vertue in such like Amulets to defend against the infection of the Plague. However," he goes on,

I will say, that if my own Life lay at stake, I should rather trust to some known Specifick Antidote than to all the fam'd Amulets in the World, tho' if the Philosophick Reason of the thing be considered and inquired into, there may be much more in it than many are aware of.

Here Salmon seems to be anticipating the supposed modern discoveries concerning the power of suggestion in treating disease or, at least, in treating some of its symptoms. But it seems reasonable to suppose that observing men must always have known this.

Shot-gun Prescriptions

Paracelsus, "the brilliant, brawling Bombast of Hohenheim," complained that "the apothecaries are my enemies because I will not empty their boxes. My recipes are simple and do not call for forty or fifty ingredients." It was indeed the heyday of polypharmacy or shot-gun prescriptions, as they are often called. Medicines were compounded of a multitude of drugs, probably with the hope that at least one of them would be effective. At present, drugs not strictly essential are sometimes added to prescriptions because it has been found that certain combinations of drugs mutually enhance each other. Such drug action is spoken of as synergistic. That anything was known of this in the seventeenth century is unlikely. But perhaps they suspected something similar, for the irrepressible Porta, in his "Magia Naturalis," advises for the purpose of mak-

ing insipid musk recover its scent to "hang it into a Jakes [privy] and among the stinks; for by striving aginst these ill savours it exciteth its own vertue." It may be that they thought medicinal agents were enhanced by a similar competition among themselves.

As the words of Paracelsus suggest, it was nothing unusual for a remedy to contain forty or fifty ingredients. The biggest charge perhaps ever ordered for a pharmaceutical shot-gun was "Matthiolus, his great Antidote against Poyson and Pestilence," which was used from the sixteenth century well into the eighteenth century. It specially mentioned 130 ingredients, ranging from rhubarb to emeralds. Some of the components of this mixture were complex in themselves, so that all told the number of substances comprising it must have approached 200. This prescription was a marvel even in its own day, and the physician Culpeper made the remark that if the formula "were stretched out and cut into thongs it would reach around the World." There was little irony in this statement, for he recommended the recipe as excellent for its intended uses.

Precious Stones, etc.

The heterogeneity and scope of the pharmaceutical armamentorium of the Restoration is well illustrated in the following prescription given by Bates. Its name is "*Lapis Contrayerva,*" a diuretic plant.

Magisteries [powders] of hartshorn,
of white and red Coral,
of Pearls,
of White Amber,
of Crabs Eyes, of each, 2 drams;
Roots of Contrayerva ½ dram;
the black points of Crabs Claws 2 ounces;
all rightly prepared; mix them together, and with Gelly of Vipers, as much as is necessary, to make it up into little Balls, which cover with heavy leaf Gold and carefully dry, according to the art. Some add to the composition Ambergres 1½ drams. It is a famous Cordial, Antidote against Poyson and Sudorifick, prevails wonderfully against the Plague, Small-pox, Measles, and all sorts of malign Fevers. Dose ½ dram.

The next is from the same book and is somewhat similar, though likely more costly. It is called "*Lapis de Goa.*" Goa is a plant, a crocodile and a city in India.

Of the Hyacinth,
Topaz,
Saphire,
Ruby,
Pearls, of each, 1 ounce;
Emeralds, ½ ounce;
Oriental Bezoar,
white and red Coral, of each, 2 ounces;
Musk,
Ambergrise, of each, ½ ounce;
Leaves of Gold, No. 40;
make all into a fine Powder, which bring into a paste with Rose-water and form into oblong balls not much unlike to little Eggs, drying them well in the Shaddow: then with a Limpets Shell, or some other thing of like nature, let them be carefully polished that they may have a Gloss upon them, according to the Art. It has the same virtues with the former. Besides which it is a Specifick against Cramps and Contractures of the Nerves.

If we could give credence to the words of Dr. Salmon these would most certainly be potent pills, for he adds:

It is an Antidote against Plague and Poison and cures the Bitings of Serpents, mad Dogs, or any other venomous Creature; it revives the Spirits, cheers the Heart, fortifies Nature, resisteth Melancholy, restores in Consumption, prevails against all Diseases of the Head and Brain, proceeding from Cold and Moisture, causing a lively Presence, nimble Wit, a pleasant Countenance and a sweet Breath.

Of course it will do nothing of the sort, except perhaps correct halitosis for a time. Most of the ingredients are absolutely insoluble, and the whole pill is so constituted that it will, most likely, pass through the system intact, much as the "everlasting pills" of metallic antimony of the same period, which were used by the whole household and

bequeathed from one generation to the next.

Precious stones were prized for all sorts of conditions. As they were only in reach of the rich there were substitutes to suit the purse. If a prescription called for emerald it could also be gotten with green glass. It wasn't quite as good, it is true, but that couldn't be expected. The London Pharmacopoea, as revised by Culpeper in 1683, gives the virtues of,

> Emerald, called the chast stone because it resisteth lust. . . . Being worn in a Ring, it helps or at least mitigates the Falling-sickness and Vertigo. It strengthens the memory and stops unruly passions of men. It takes away vain and foolish fears, as of Devils, hobgoblins, &c. and causeth good conditions; and if it do so being worn about one reason will tell him, that being beaten into a powder and taken inwardly it will do much more.

Personally Culpeper had his doubts, for he concludes the chapter with, "Thus I end the stones, the Vertues of which if any think incredible I answer, 1. I quoted the Authors where I had them. 2. I know nothing to the contrary but why it may be as possible as the sound of a Trumpet is to incite a man to valour, or a Fiddle to dancing." In other words, he means to say that the value of these indestructible medicaments is psychological alone.

Detoxifiers

Bezoar, mentioned in a previous panacea, like ambergris, was an intestinal concrement, but derived from certain herbivora instead of from whales. Notwithstanding its ignoble origin, it could well be put into the category of precious stones, for it was worth many times its weight in gold. Bezoars had been popularized by the Arabian physician Avenzoar in the twelfth century. The name means "expeller of poisons," and detoxification was their chief alleged virtue.

Besides being taken internally, they were preserved as charms in gold and silver caskets. During the plagues they were rented out for large sums. An eastern nabob once sent one to Queen Elizabeth of England. Later, bezoars were discovered in Europe, but, as is usual, the domestic variety was considered inferior to the imported.

Somewhat related to bezoar in its usefulness was the horn of that *rara avis in terris*, the unicorn. Its field of operation was also detoxification, and it worked as effectively outside of the body as within. Horns of this fabulous animal were in especial demand by royalty who were in constant fear of imbibing some subtle *poudre de succession*, surreptitiously added to the royal beverages. The hollow unicorn horns were a very good protection against the consummation of such dark forebodings, for all that was necessary was to allow the liquor to stand in one of those magic containers a short time, and old King Cole might enjoy his pipe and his bowl and his fiddlers three without any sinister ruminations to mar his evening's fun. Some one gave Henry II of France one of these horns which was seven feet long, large enough by all odds to innocuate several bootfuls at once.

Shortly after the start of the whaling industry the unicorn horn vendors must have turned their mercantile talents to things like the London Bridge. At any rate their business must have gone to pot, for a pharmacists' dispensatory in 1733 informed the erstwhile duped world that "the Unicorn . . . is a great fish found in Davis' straight." It goes on to say that "what's commonly sold for Unicorn's horns is nothing else but bones of Whales, Sea Horses [walruses], or Elephants, which are brought by art into that shape."

Dabblers in Medicine

Up to the middle of the eighteenth century there had been many physicians of well-deserved fame who were not doctors of physic at all but merely "stu-

dents of physic," as they liked to call themselves. Even more numerous than these were those who just dabbled with medicine. It was not till 1748 that Parliament restricted the practise to those academically qualified. The celebrated Nicholas Culpeper himself entered the profession *via* the apothecary's shop and never had a degree; yet he was the author of half a dozen medical books which were very popular in England and colonial America. Perhaps the most notable dilettante of this sort was the Hon. Robert Boyle, F.R.S., the renowned "father of Chemistry." In the great and protean list of his publications is a little book entitled "Medical Experiments, or a collection of choice and safe Remedies, for the most part simple and easily prepared: Useful in families and very serviceable to country people." Boyle was without question the most famous scientist of his day, and his exceptional ability might give rise to the expectation of finding in this volume some real improvement over the advice offered by his contemporaries. But alas! about the best one can say for his remedies is that they are simple, though perhaps, in a different sense than he intended.

His advice "To clear the Eyes from Films" goes that somewhat paradoxical, popular expression of benevolence, "Here's mud in your eye!" several better and even attempts to put it into practise. It directs that one

> Take Paracelsus's *Zibethum Occidentale* (viz. human Dung) of a good Color and Consistence, dry it slowly till it is pulverable; then reduce it into an impalpable powder; which is to be blown once, twice or thrice a day as occasion shall require, into the Patients Eyes.

Boyle graded his recipes alphabetically, according to their supposed values. This one ranked an A. Doubtless the afflicted ones were not supposed to guess what sort of treatment they were being subjected to under the high-sounding name of *Zibethum Occidentale*. Suffering with a malady of such a nature, Boyle perhaps supposed they would not be able to read his parenthetical explanation of the term. Otherwise one might imagine that they would utter a determined protest, as did the prophet Ezekiel when Jehovah ordered him to bake his food with this material. (See Ezek. 4: 12–15.)

To most people the pungent odor of the genuine civet is anything but pleasant, but it may well be imagined that, instead of going to the "jakes" for "occidental zibet," the afflicted one would be willing to tap his cane along the broken pavements and mud-gutters to the nearest chemist's shop and say: "Give me a dram of civet, good Apothecary." Nor would he forget to add, "And I don't want anything 'just as good' either."

One is tempted to say it is eminently fitting that the great Boyle should prescribe for little boils and kindred evils. Here is a first-class formula "for Ulcers of the Breast and elsewhere:"

> Take *Millepedes* (in English by some called Wood lice, by others Sows) and having washed them clean with a little White-whine and dry'd them in a Linnen Cloth, beat them very well in a Glass or Marble Mortar (for they ought not to be touch'd with anything of Metal) and give the first time as much juice as you can by strong Expression obtain from 5 or 6 of them. This juice may be given in small ale or White-whine, in which the next time you may give as much as may be squeez'd out of eight or nine Millepeds; and so you may continue, increasing the number that you employ of them by two or three at a time till in amount twenty-five or thirty; and if need be forty or more for one taking.

Perhaps the *rationale* of this treatment was that the ulcers would take legs unto themselves. At any rate it seems to have been a good cure, for in the "New English Dispensatory" of 1733 "that honour to our country Mr. Boyle" is commended for it, though he, no doubt, was not the originator.

"For Difficulty of Hearing from a

cold cause" this eminent savant suggested:

> Out of the Bulb or Root of Garlick, chuse a chive of convenient Bigness; then having pass'd a fine piece of Thread or Silk through one end of it, that thereby it may be pull'd out at pleasure, crush it a little between the fingers and having anointed it all over with the Oyl of Bitter (or in want of that Sweet) Almonds, put it into the Cavity of the Patients Ear at Bedtime, and draw it out the next Morning, stopping the Ear afterwards with Black Wool, but if need require this Operation is to be reiterated with fresh Garlick for some days successively.

Garlic-bulbs seem to have borne the divine inscription of suppositories, for they were freely recommended for all the cavities so medicated.

It seems unfair to quote so much from the unofficial exponents of the healing art, but some of their recipes were so titillating that it would be a shame to pass them by. "Against the colic," medicaster Porta writes:

> Civet is most excellent in this disease: for the quantity of a Pease applied to the Navil, and a hot Loaf out of the Oven clapt over it, presently easeth the Pain: the Patient must ly on his Belly upon the Bread before it is cold.

The Virtues of Tobacco

Tobacco had been introduced into England from America about the beginning of the seventeenth century and, though it had been the subject in interdictions both sacred and profane, its medicinal use must have been sanctioned by special dispensation, for by the middle of the century it had been learned that,

> Out of the seed of it is expressed an oyl . . . , which allays the cruel tortures of the gout; the juice clarified and boiled into a syrup and taken in the morning, maketh the voyce tunable, clear and loud; very convenient for singing Masters. If you bruise the leaves and extract the juice it killeth the lice on childrens heads, being rubbed thereon, the leaves cure rotten Soars and Ulcers, running on the legs, being applied unto them.

In this connection it may be well to sound a warning against the indiscriminate use of the "oyl of tobacco," for the Royal Society, in its early days, found by experiment that one drop of it was fully as efficient as curiosity in killing a cat.

The discovery of new virtues of this versatile weed seems to have continued, for an early nineteenth century pharmacopoeia lists a tobacco enema. About the same time the surgeon and anatomist, Sir Ashley Cooper, recommended this in a heroic dose as a preliminary to reducing difficult hernias, because it caused such extreme languor that the patient had "not the power to exert any of the voluntary muscles of the body," thus, almost repeating the Royal Society's classic experiment on the cat.

Cosmetic Medicine

Most medical works of the Dark Era contain a section headed "*De Decoratione*" or something similar. From the beginning of the seventeenth century a great part of this fertile field seems to have been alienated from the medical realm. The cosmetic methods employed are often very amusing. In the third book of the *Brevarium Practicae*, Arnold de Villanova (1235–1320) says, "In this book I intended, God being my helper, to treat of the sicknesses which especially concern women, and as women are in general venomous animals I shall follow it up with a treatise on the bites of venomous animals." But though he thinks them venomous, he at least would like to have them comely, and he, accordingly, interjects a long chapter on female adornments. A large portion of the advice offered in material of this sort treats of dyeing the hair of the scalp, eyebrows and eyelashes, making it grow or removing it, painting the face, removing wrinkles from various parts and all the other alterations in which the present era is so proficient.

Involuntary epilation appears to have been a problem from the earliest times, and remedial prescriptions seem to have been as numerous throughout the ages

as they are to-day. A very highly recommended medicament directed at this distressing state comes from the Gaelic:

> With mice fill an earthen pipkin, stop the mouth with a lump of clay and bury it beside a fire, but so as the fire's too great heat touch it not. So let it be then for a year, and at the year's end take out whatever may be found therein. But it is urgent that he who shall lift it have a glove on his hand lest at his fingers' ends the hair come sprouting forth.

Almost as numerous as the methods for growing hair are those designed to remove it. One given by the somewhat occult but encyclopaedic Giovanni Baptista Porta in his *Magia Naturalis* (English Translation, 1658) directs that one,

> First foment the part with hot water, and pull out the hairs one by one with women's nippers: then dissolve Salt Peter in water, and anoynt the holes where the hair grew. It will be better done with oyl of Brimstone or of Vitriol [sulphuric acid]; and so they will never grow again; or if they do after a year, they will be very soft: do then the same again and the parts will be bare always.

"So," the author asserts, "I have made many a womans forehead longer, and have taken off hair from parts hotter than the rest."

The same author offers a timely solution as to how a "woman deflowered [is] made a virgin again."

Absent Treatment

Absent treatments were perhaps as popular three or four centuries ago as they are to-day. Paracelsus was a great advocate, if not the author, of one of these, for healing wounds. The application was, curiously, not to the injured part but to the object responsible for the damage. This was the notorious "weapon salve." It was supposed to operate through the mediation of magnetic rays passing from the weapon to the wound. The ointment was prepared as follows:

> Take of the moss growing upon a dead man his skull, which hath laid unburied, two ounces, as much of the fat of man, half an ounce of Mummy, and man his blood; of linseed oyl, turpentine and bole-armick [Armenian clay] an ounce: bray them all together in a mortar, and keep them in a long straight glass. Dip the Weapon in the oyntment and so leave it.

Further directions were:

> Let the Patient in the morning wash the wound with his own water; and without anything else tye it up close and he shall be cured without pain.

Perhaps this was better treatment than many others current at that time, for even taking into account the morning ablution, the method at least tended to keep the wound from much additional contamination, which many of the others did not. Besides the here-mentioned use, briny effluvia of this nature had a variety of others, among which were to relieve dyspepsia and constipation and as a lotion for the skin. Curiously, a variety of skin disorders are still popularly treated in this fashion. Preparations from dead men's skulls were even more highly esteemed. Their special domain was in disorders of the brain. Just before muttering his dying wish, "Don't let poor Nelly starve," Charles II drank a jigger of one of these preparations.

Sympathetic Remedies

An equally irrational type of treatment was the "sympathetic powder" of Sir Kenelm Digby, an English physician and courtier of the time of Charles II. This nigh omnipotent powder was nothing more than green vitriol or iron sulfate. "The rays of the sun," Digby explained, "extracted from the blood and vitriol associated with it, the spirit of each in minute atoms. These combined in the air, and the air charged with the atoms of blood and vitriol, were attracted to the wound and effected the cure." The famous chemist and physician, van Helmont, who first produced coal gas, was one of Sir Kenelm's col-

laborators in the writing of a book on this brand of treatment. Van Helmont had at one time been almost killed by a very unsympathetic cathartic prescribed for the itch, and that fact may have had something to do with his alliance with Digby and his "sympathetic" medicines.

Sir Kenelm gives one for whooping cough, in which the patient's nails are to be pared and the parings enclosed in a little bag, the bag to be hung about the neck of a live eel and the eel to be placed into a tub of water. "The eel," he assures, "will die, The patient will recover." Whether the cause of death in the eel will be whooping cough or strangulation he leaves unmentioned.

What corruption was sometimes considered necessary to combat corruption, under this "systematic" system, is seen from van Helmont's prophylactic against the plague.

> Large old frogs caught in the month of June and hung up by their hind legs over a dish covered with wax which has been placed over a moderate fire. After a few days the frogs discharge terrible fumes and slaver which attracts every kind of worms and flies. These stick to the wax and add their own drivel to the mess. When the frogs are dead, roast and mix them with the carefully preserved wax and drivel and shape this compound into small rolls, or imitate the shape of frogs. One of these is sewn into a cloth and worn in the region of the heart suspended by a silk thread around the neck.

According to the author, this was such a remarkable remedy that before the publication of his book it had "gained such a reputation throughout the country that all 'barbers and blear-eyed witches' are already acquainted with its virtues."

Conclusion

It is a far cry from the optimistic credulity of that day to the sceptical science of ours. The hit-or-miss symptomatic dosage of former times has gradually given way to a rational therapeusis, directed at the cause rather than the effects of disease. Such treatment rests on a sound knowledge of the pathology concerned and the agents of causation. In the seventeenth century such knowledge was almost nil and even at present is very defective. In all justice to the healing art of bygone days, it must, however, be admitted that the treatment of not a few diseases is not much better now than it was then, and everything considered some of the cures were truly remarkable. Judging only from the remedies quoted in this article, this statement, of course, would fall somewhat short of substantiation, for only the most ludicrous therapy has been considered. If a man irrigates his eyes with boric acid solution it is not news, but if he employs Boyle's dusting powder it is.

TERRITORIAL EXPANSION

A STUDY IN POLITICAL GEOGRAPHY

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THE significance of political geography has been recognized by a number of American geographers; for example, Bowman devotes much attention to it in "The New World," as does Semple in "Influences of the Geographic Environment," and Brigham in a number of writings. Moreover, two chapters are devoted to it in the widely used college text-book, "Principles of Human Geography," by Huntington and Cushing. Nevertheless, it has not received the attention in American universities that it merits. Tower, to be sure, gave a course in political geography at Chicago from 1912 to 1915, and Whittlesey one there for some years later. During recent years, Hartshorne has given a course at Minnesota, and Whittlesey intends to introduce political geography soon at Harvard, and Van Valkenburg at Clark. Apparently, therefore, the complications and uncertainties introduced by the world war, the growth in interest in regional and economic geography and the strong movement towards the factual, descriptive geography merely have postponed the adequate exposition of political geography in American universities.

The following generalizations as to territorial expansion are offered in the hope that such hypotheses as these will stimulate thought, increase observation and lead to the gathering of more facts in this socially significant division of geography.

I. COUNTRIES TEND TO INCLUDE SOME SEACOAST

Nearly all the countries of the world border the sea. The exceptions are Bolivia and Paraguay in South America, Ethiopia (Abyssinia) in Africa, Afghanistan, Bhutan and Nepal in Asia, and Switzerland, Czechoslovakia, Austria, Hungary and the tiny, mostly mountain, states of Andorra, Liechtenstein, San Marino and Luxembourg in Europe. Of these fourteen, only the four larger central European countries are commonly considered of world significance, and only Switzerland of these four antedates the world war as a country lacking coasts. This coastal distribution of countries is largely a result of the facts that (a) those countries which started in the interior, and have survived have nearly all expanded until the coast was reached. (b) Many additional countries started as coastal colonies. Both of these statements are true largely because the sea is the world's great highway. As commerce upon the sea has increased, so had the desire to reach the coast, despite the fact that since railroads have become available the sea is no longer nearly so overwhelmingly important as a commercial highway as it formerly was.

The fact that the sea is the source of a significant amount of fish and other sea products increases the desire for ready contact with it. Sea food was formerly so much more significant than it is now that it is hard for us beef, wheat, sugar and fruit eaters of to-day to realize how important fish formerly were in the diet.

A third reason for the desire of statesmen that their country reach the sea was that it was considered to be the most satisfactory boundary to a realm. It was thought of as definite, and suffi-

ciently isolating so that there would usually be far less trouble in respect to the entrance of armies, or of expanding peoples, than there would be along most other boundaries. From the standpoint of tariff levying, the coast was considered to be a desirable boundary also, because goods which enter a country and are subject to a tariff tax can enter at fewer points, normally, than across most other kinds of boundaries.

It is now generally considered so desirable that a country extend to the sea that Poland was given a "corridor" to the Gulf of Danzig, despite the fact that this separates East Prussia from the rest of Germany, and introduces several annoying complications. In other instances the League of Nations has augmented the internationalization of certain rivers—for example, the Danube and the Rhine—to permit the commerce of inland countries to reach the sea more readily. Certain ports in other countries are also directed by the League to be made available to the use of certain inland countries. For example, Fiume, in northeastern Italy, and Susak in Yugoslavia may be readily used by Austria and Hungary.

The expansion of inland political centers to the coast has been aided by the fact that, if the area below is not strongly occupied by an unfriendly people, it is easier to trade and expand down a valley than up one. The extent of coast held by a country depends, therefore, partly upon the distribution of rivers leading to the coast.

In the past, when river commerce was highly important, it was considered especially desirable to control the mouth of the river. For example, one of the advantages of the Louisiana Purchase stressed at the time was that as a result of that purchase the United States controlled the mouth of the Mississippi River, then considered to be the chief outlet for the future exports of the midwest.

The seacoast is more important now as an international boundary than it was 400 years ago, before the sea was much used as a highway, and when each locality was largely self-sufficient. Then most of the numerous principalities were interior lands, and some of the strongest—for example, Austria, Bavaria, Burgundy and Russia—did not reach the coast.

II. Superior Seaports Tend to Be Incorporated into the Stronger Country Nearby If Situated So As to Serve It Advantageously

Not only do nearly all countries reach the coast, but there is a strong desire for superior seaports, for only by means of ports is an effective contact made with the sea. A good harbor, if well situated, may indeed, have naval or even commercial value although it has only a poor hinterland. Conversely, a poor harbor may become a significant port, provided there is no better harbor available to serve a rich hinterland, as is proven by the fact that some of the chief ports have harbors that are largely artificial. But what is most desired, of course, is the combination of a good harbor and easy access to the hinterland.

Numerous countries have illustrated the principle that strong countries tend to expand so as to obtain the best ports readily available. Russia's expansion before 1914 was much influenced by the desire of her leaders for a good ice-free harbor. America's boundary at the extreme southwest was placed far enough south so as to include San Diego, with the best natural harbor within a long distance. The Virgin Islands were purchased largely to obtain the harbor of St. Thomas, considered especially desirable as a base for naval operations in

the defense of the eastern approach to the Panama Canal. Italy's recent expansion eastward to include Trieste and Fiume was influenced by the fact that these ports are far better than others in northeastern Italy. This expansion took place almost as soon, as these, as the result of the dismemberment of Austria-Hungary, were in Yugoslavia, a less advanced country industrially and commercially than Italy.

The tendency for the stronger country to include good ports has been so great as to justify the generalization that, in the past, where a superior harbor or port was situated near the boundary between two countries of unequal strength it generally was incorporated within the stronger of the two countries; if not originally, then eventually, provided it could advantageously serve the stronger country.

III. Active Countries Tend to Expand into the Sea to Include Nearby Islands and Sometimes Coastal Areas Opposite

A third great generalization as to territorial growth is that the stronger countries expand to include nearby islands. So many islands have been annexed by nearby mainland countries that it is hardly worthwhile to cite examples.

The geographic bases of this annexing of islands are (a) the interest of the people of the continental area in the fish of the sea, and in the islands as a base for fishing, drying the fish and trade. (b) The further fact that island peoples, with few exceptions, have less diverse and abundant resources and fewer means of making a livelihood than are present in most neighboring continental areas is also of importance. As a result of a restricted environment, the people of islands generally lead a relatively simple life, and are less prepared to meet unusual conditions than are the people in continental areas. Biologically also, island peoples and the lower animals and the plants as well are, with few exceptions, less diverse and resourceful or capable of extensive adaptation than are those of continents. Hence, when competition occurs, the insular forms usually lose out in the struggle. The chief exception to this latter rule is afforded by especially favored islands, such as Great Britain and Honshu. Although both of these were conquered by peoples from the mainland, these islands, because of a fortunate combination of conditions, not only later became independent but expanded and incorporated smaller islands nearby, and also more distant islands and lands across the sea. Japan's annexation of Formosa and Korea are examples, as are Britain's annexation of the Isle of Man, the Channel Islands, Ireland, and for a long time parts of western France. But Great Britain and Honshu are clearly continental in resources rather than typically insular.

This tendency for strong countries to expand into neighboring seas has led several to expand across such seas and to include areas on the opposite side which are geographically less well endowed. Illustrations are the French, Italian and Spanish expansion into North Africa, the fact that Sweden long included Finland, and Denmark long controlled Norway.

IV. A Natural Geographic Unit Tends to Become a Political Unit

There is a strong tendency for a natural geographic unit such as an island, a peninsula, a plain set off by mountains and the sea, or an area of similar climate, to become a political unit. The rapidity of consolidation depends partly upon the comparative strength of the peoples and leadership within the area,

and partly with its geographic distinctness. For example, different parts of the island of Great Britain were for a long time held by various almost equally strong peoples and political units, with a result that centuries were required for it to become politically united. On the other hand, there was such a disparity in strength between the English-speaking people and the aborigines there that "temperate North America" was nearly all united comparatively promptly. The exception is the southern section of Canada, that belongs in this large geographic unit but which formerly contained a predominance of French-speaking people. Australia affords an even better illustration, as no part is excepted. Another excellent example is Russia, which started in the western part of the world's most vast plain and expanded until almost all the plain was annexed. Towards the east, northeast and southeast, expansion was easy, as in those directions the Russians encountered less energetic, less well-organized and less advanced peoples. Towards the west, however, they met stronger peoples and made little progress. Indeed, since 1917 Russia has lost nearly all the territory in that direction which had been previously laboriously won. Likewise the consolidation of the rather distinct geographic region of France into one country required centuries to consummate, partly because at the northeast there is no distinct natural boundary, and the people involved were highly energetic. There has been more fighting in that section to gain or to hold a comparatively few thousand square miles than were required to incorporate most of the rest of France.

Regions that are set off geographically have tended to become politically consolidated in response to three main influences. (a) Such regions, being rather homogeneous geographically, tend to become relatively homogeneous in respect to population, language, economic conditions and social ideals, as a result of an intermingling of peoples. This approach to human unity makes powerfully for political unity. (b) Another great unifying force is the fact that geographically distinct regions necessarily are set off from other regions by barriers of some sort; the sea; rugged zones, such as a mountain range, or belts that are unfavorable to close habitation because of aridity, marshiness or poor soil conditions. Such surrounding scantily peopled zones increase the tendency for the people in the better settled area to unite politically by increasing their bond of kinship racially and socially. In the isolating zones there are either no people, as on the sea or in lofty mountains, or else very few and mostly rather poor people, as in rugged, dry, marshy, rocky or sandy zones. Such people are likely to be sufficiently different culturally from the people of the more densely peopled area so that they are bound to them culturally by only relatively weak bonds. The tendency for a country to expand to reach the sea, mentioned earlier, is another influence leading to the consolidation of natural geographic units. The tendency to expand to reach the other sorts of isolating barriers is less strong and usually slower and less intentional than is the expansion toward the sea. Much of it comes about as a result of the slow spread of people and culture out from the richer parts of the natural region. However, the fact that mountains commonly have been considered to afford protective boundaries because of the difficulty with which they formerly were crossed, has had a considerable effect in encouraging expansion to the mountain barrier, if one is convenient.

(c) A major reason why there are so

many countries in Europe is because there are so many rather distinct geographic units in western and southern Europe, each of which has tended, in keeping with this principle, to become a separate country. The eastern part of Europe with its vast plain contains chiefly only one country, while the remainder of Europe with its many islands, peninsulas and other areas, somewhat set off by mountains or sea, contains many countries. Because of the historical significance of the numerous political entities of Europe it will be worthwhile to briefly sketch the situation in Europe from this point of view.

European islands containing independent, semi-independent or formerly independent countries are Great Britain, Ireland, Iceland, Crete, Corsica, Sardinia and Sicily. Peninsulas occupied by independent nations or two or more countries are Jutland, Italy, Greece, Scandinavia, Iberia and the Balkan Peninsula. Two others, Crimea and Brittany, formerly contained distinct political units.

The sea has been of significance in setting off certain European countries, in addition to the islands and peninsulas already mentioned. For example, the essentially coastal countries of Finland and Estonia are separated by the Gulf of Finland, and Estonia and Lithuania are partly divided by the Gulf of Riga. East Prussia, also primarily coastal, is separated from Poland partly by the Gulf of Danzig.

The mountain ranges of Europe have also played a part in increasing the number of political units. Since the eleventh century the Pyrenees have generally served as a political boundary; Italy and its predecessors, if the rather loose Holy Roman Empire be excepted, have seldom extended beyond the Alps, nor has modern Germany or France. The Kjolen Range helps separate Norway and Sweden; and the Karpathian Mountains, with their southern extension, the Transylvanian Alps, have repeatedly served as political boundaries. Similarly, Bohemia, surrounded on three sides by low ranges, has had a considerable degree of economic independence and political individuality. Mountain ranges have also been significant in delimiting countries in the Balkan Peninsula.

Other sections of Europe are set off in part by other types of physical features. For example, a marsh has partly separated the Netherlands from Germany throughout the last 400 years. Marshes formed parts of the boundaries of several German states that were independent before 1871, and the extensive Pinsk Marsh helps separate Russia and Poland. Lakes have played a rôle, too, though a minor one. For example, the eastern boundary of Estonia is mostly formed by Lake Peipus, the southeastern boundary of Finland by Lake Ladoga, and parts of the boundary of Switzerland by Lake Geneva and Bodensee (Constance).

With physical features tending to divide Europe into so many separate units, it has been only since facilities for transportation and communication have become generally efficient that the influences tending to unite western Europe politically have been at all strong in comparison with the influences tending to divide it into many units. Even the "Pan-Europe" dream does not include Britain, set off by the sea, or Russia, which because of its vast territory in, and wide contact with, Asia is often thought of by Western Europeans as semi-Asiatic rather than as European. However, from the viewpoint of the world as a whole, Western Europe of to-day comprises, as a result of efficient transportation and communication, a single geographic unit, more

distinct geographically than is "Temperate North America" or Chile; and hence, according to the principle of political geography under discussion, it presumably will ultimately function as a unit in many respects. Because of the human barriers imposed by differences in language, laws and the tariff, it appears, however, that any considerable amount of unification must await a considerable increase in commercial and cultural exchange.

The tendency for a climatic region to consolidate politically was illustrated by the Roman Empire, which was essentially the Old World region possessing a Mediterranean type of climate. It only extended widely beyond this limit for comparatively short times, and incorporated regions in diverse climatic types far less completely than it did regions with the Mediterranean climate. Similarly, the Islamic World has been essentially the Old World desert and its borders. Russia, too, nearly all possesses the continental type of climate. Since 1917 the parts of the former realm that were less intensely continental, the western zone bordering the Baltic and south from there, seceded. These areas had not become an integral part of Russia partly because the climatic conditions were sufficiently different from those of most of Russia so that the manner of living was different. The United States is likewise nearly all of one major climatic type, the continental, despite the inclusion of narrow strips of the Mediterranean, marine and semi-tropical climates.

Northwestern Europe is climatically decidedly homogeneous, of the marine type, but the southern part of Western Europe is of a different climatic type, the Mediterranean. What part of the failure of the people of the three great climatic regions of Europe, the marine, the Mediterranean and the continental, to understand each other is due to the differences in climate it is impossible to say, but doubtless a considerable share. The fact that most of the people of the continental climatic type are of the Slavic subrace, while those of the marine climate are largely dominated by the Nordic subrace, and the Mediterranean by the subrace so named suggests the fundamental importance of the climate. These climatic and racial differences supplement the physical features in retarding the unification of Europe.

V. Areas Having Similar Cultures Tend to Unite Politically

Not only does a natural geographic region tend to unite politically, but where the culture of that natural region has extended beyond it, such outside areas also are likely to come to be united politically to the cultural homeland. Since one of the conspicuous and most significant elements of advanced cultures is the written language, this generalization is illustrated by the uniting of peoples using the same language. Modern Germany not only includes many formerly independent principalities in the North European plain, but also various formerly independent principalities somewhat isolated by mountains. The fears of leaders in other countries have been the chief influence recently to prevent the uniting of post-war Austria, with its predominantly German language and culture, with Germany. Likewise, modern Italy includes not only the natural geographic unit but also various nearby areas containing many people who consider themselves Italians.

This principle is well recognized in international law, where it is held that the best claim to sovereignty over an area is its permanent occupation by nationals of the claiming country and

their descendants, and the maintenance of contacts between the two. Neither discovery nor a formal declaration of annexation are comparable in validity in international law to this cultural bond.

VI. Geographically Favored Regions Tend to Become Strong Countries

The generalization that a natural geographic unit tends to consolidate politically and belong to one country leads to the development of countries of diverse size and natural wealth, because the natural geographic regions differ widely in these respects. Where the natural unit is poorly endowed, only a weak country can result, so long as it is confined commercially and otherwise to that unit. Conversely, where the natural unit is well endowed, the resulting country readily becomes strong. The strength of France as compared with Spain, of Germany as compared with Hungary and of Italy as compared with Greece are illustrations of this rule.

As the resources of any region are at first not effectively used, a country may grow in comparative strength while its resources are being developed, or it may decline as compared with other countries, because its rivals are developing resources which they formerly did not use. For example, when agricultural wealth was of preeminent importance, France had a greater advantage over Germany than when minerals became highly useful, for Germany has much more coal and potash than France. Furthermore, Germany used her remarkable potash deposits to overcome part of her handicap of poorer soils. Similarly, now that Norway's water power is coming to have value, Denmark no longer has such a great advantage as formerly, when it had no value and agriculture was predominant, when for centuries Denmark dominated Norway politically. So too, Switzerland is comparatively far better off now, when its water power can be used advantageously, and when many tourists come to enjoy its scenery and climate, than it was when the higher sections of the country and the steeper slopes had almost no value.

Consequently, the strength of a given area varies from time to time with the advancement of civilization and the market for its resources; but, nevertheless, the geography of the area determines to a large extent its comparative wealth and has a great deal to do with the strength of the country occupying it.

VII. Weaker Countries May Be Annexed to Stronger Ones, Not the Reverse

A comparatively strong natural geographic unit, after it has been consolidated into a country, tends to expand so as permanently to include weaker units adjacent or convenient. This has often been noticed, but the reasons for it are often overlooked, as is the fact that history affords practically no examples of the reverse taking place, geographically poorer countries annexing richer ones, despite the aggressiveness of some leaders of poorly endowed countries. Three reasons why it is always the stronger country geographically that expands, and not the one that is stronger in its military organization or in the ambition of its leaders, are:

(1) Annexation requires more than temporary conquest. Although the people from a weaker area may be physically strong and daring, and under primitive conditions sometimes better fighters, they lack the cultural strength which predominant numbers give. Hence, they relatively soon have lost control. Under modern conditions, even war, with all its barbarism, requires so

much scientific knowledge, systematic cooperation and utilization of resources, that a geographically weak country, with its lesser resources, small population of advanced individuals and its handicaps to cooperation, is at a very distinct disadvantage and has small prospect of winning a war against a more favored country, and, as already remarked, even less chance of retaining its conquests if, because of superior leadership, it should win. Paraguay affords a good illustration. Under Roca, conceded to have been a military genius, Paraguay waged war against Brazil and Argentina. But, despite Roca's predominant skill, the stronger countries won.

(2) Another reason why the stronger country expands is due to the fact that the limited resources of the poorer area can be more advantageously used in the richer one with its more diversified activities, larger population, better contacts with the outer world and greater capital. As a result of this, there commonly is a considerable development of the resources of the poorer area after annexation and increased prosperity in both. If the poorer area annexed the richer one, the lack of experience and capital of the leaders in the poorer area would cause a decline in the richer area.

(3) Moreover, the market for the exports of the weaker area is normally in the adjacent stronger area, and as annexation facilitates the exchange of goods, it is often desired by the weaker area, whereas richer areas would not gain by being under the control of a weaker one. An example of the desire of weaker areas to be annexed to stronger ones is afforded by the Hawaiian Islands, which applied for annexation to the United States chiefly because such annexation would be advantageous to them, as after annexation there was no tariff barrier against their sugar and pineapples.

An understanding of this rule that stronger areas annex weaker ones and never the reverse will have in general a desirable effect by reducing ungrounded fears, for example, that countries that are, in fact, decidedly the weaker geographically could possibly conquer far stronger ones. The reduction of such fears will make for disarmament and for international peace.

The tendency for the geographically favored countries to annex less favored areas does not imply, therefore, that these weaker areas are necessarily forced into the union or are in any way harmed by it. Indeed, if it were not for the fears of influential persons in other countries, doubtless several geographically weaker countries would promptly unite with stronger ones. A recent case is Austria's desire to join pre-Nazi Germany, and Luxembourg's overwhelming vote to join France, which country refused, however, and hence Luxembourg attached itself to Belgium.

Economic considerations encourage annexations, or at least close cooperations, and economic influences are likely to gain in strength with increased international trade and with the decline of the spirit of nationalism, which decline is a logical result thereof. The League of Nations and the proposed "Pan-Europe" are results of this tendency.

An influence working against territorial growth of the strong countries is the fact that areas that are geographically poor often are a financial burden to the annexing country. For example, most of the French possessions are a fiscal liability, even ignoring their influence in increasing the expense of the military machine of France. The Philippine Islands are a heavy drain upon the American treasury when the effect of their possession upon the cost of the navy is considered.

The expansion of the richer countries is stimulated, however, by the spirit of

nationalism. Nationalists take pride in having the additional area and population and in wide-spread colonies. As the spirit of nationalism weakens, with the growth of international contacts, various "possessions" will presumably either be set free or else incorporated with other units which are in position to serve them at a lesser cost. The mandating of German Southwest Africa to the Union of South Africa, instead of its control from London, is an example of this logical trend, as is the almost complete independence of Australia, which now even has a navy for its own protection and was given a mandate over former German possessions not far away.

VIII. The Number of Independent Political Units Tends to Decrease

There are to-day only a fraction as many independent political entities as there were a century or two ago. The creation of several new European countries as a result of the world war and the arrival of a number of the British dominions to the status of "Members of the League of Nations" might be interpreted as an indication that the tendency towards consolidation has run its course. But the characterization "independent" in the generalization has especial significance. Many of the so-called independent countries of to-day are, in fact, not independent, and even the most powerful are surrendering voluntarily more and more of their independence in respect to international affairs, and even in respect to many internal affairs. They are binding themselves increasingly to observe various international agreements and are submitting more and more to various international tribunals. In doing this they profit in many ways, but at a loss of a considerable degree of independence.

IX. The More Favored Regions Geographically Tend to Influence Increasingly the Less Favored

Whereas formerly most people were little influenced by those of other regions, because each locality lived largely unto itself, the situation has changed as a result of the tremendous growth of commerce and the spread of culture. It is trite to say that the world is all bound together, but it is not adequately realized that nearly all this uniting influence comes from the people in or from the geographically most favored areas, which have come to have an augmented advantage in many respects over the people in the less favored areas and to influence them more and more. In other words, European or Western civilization has spread, and is spreading to-day probably more rapidly than ever before. The political domination of Europe over the other parts of the world is at present almost complete, except so far as it has been tempered by a relegation of authority, including the granting of independence or semi-independence to regions which are dominated by European ideals if not by European individuals.

Americans may feel that America is an exception to this rule, but if they do so, this attitude illustrates their failure to realize that America is, in fact, largely an offshoot of Western Europe, and enormously influenced by it.

This augmenting dominance of the especially favored areas results inevitably from the increasing demands made by rising standards of living accompanying higher civilization with all that these higher standards imply. The less favored regions simply can not supply the material or cultural demands made by the awakening people of those less favored areas. Hence, they tend voluntarily to submit themselves to the eco-

nomic and political domination of the people in the more favored areas who can supply a larger share of the desired goods, capital and culture.

X. Political Control is of Increasing Significance

Another great trend is that governments have become increasingly significant. Before the modern era most communities lived so largely a local existence that it perhaps made little difference in what country it was situated. With the introduction of improved transportation and communication the situation has changed, however, and now the influence of the government is strongly felt in every part of all the more advanced countries, and it may make a great deal of difference to a community which country it is within.

However, if tariffs are reduced to the extent that many economists think rational, if expenditures for military purposes are greatly reduced and if all well-peopled regions are served well by transportation facilities, medical science and other cultural forces, then it will again matter less to which country an area belongs. In the distant future the world may conceivably be divided politically into almost as many states as there are areas having people significantly different in race or special interests. These various states will presumably resemble the American states, however, in that their independence will be strictly limited, and also in the fact that from some central agency, funds and leadership obtained from the richer areas will aid in the utilization of the natural and human resources of the less favored areas. Only by such outflow from the geographically favored areas can the poorer ones continue to be highly civilized and enabled to make their own contributions to civilization. Although these outflows of capital and skill must be greater from many areas than can be compensated for permanently in kind by the less favored areas, there are other sorts of return. The Philippine Islands, for example, have been worth much in the education of the American people.

SCIENCE AND THE LAYMAN

By Dr. BENJAMIN C. GRUENBERG
ASSOCIATE IN SCIENCE, AMERICAN ASSOCIATION FOR ADULT EDUCATION

PEOPLE go to the library for books, they buy magazines, they write to the editor, they consult an expert, they discuss with their neighbors. They do one or several or all of these things in order to get information that will enable them more satisfactorily to operate their radio or motor boat, to mix and apply paint or concrete, to bait a hook, to redecorate their homes, to improve their golf or card game. All this is adult education. And some of it has to do with science.

The most widely felt needs for scientific information or guidance are related to technological applications. These needs manifest themselves in mechanics institutes and in agricultural extension courses. There is a constant demand for instruction in the better care and feeding of children. Thousands of books and pamphlets are used up to enlighten folks on the workings and management of internal combustion engines and chicken farms.

Various studies indicate that over a long period there has been a trend toward greater interest in science on the part of the general adult public. Parallel to the increase in high-school and college enrolments, since the beginning of the century, there has been a marked relative increase in the circulation of popular science magazines, as also in the number of science articles in the general magazines. There has also been a very striking increase in the amount of space given to science topics in the newspapers, especially during the past ten years. On the other hand, the organized instruction of adults in the natural sciences does not seem to keep pace with the amount of instruction in these fields offered in high schools and colleges. Whereas the schools have been giving about 10 per cent. of the students' time to the sciences, and the colleges about 15 per cent., the extension classes and other voluntary study groups for adults offer science to approximately 4 to 6 per cent. In England also, and in other European countries for which information is at hand, about 5 or 6 per cent. of the adult educational activities are in the sciences. Half a century ago, some 50 per cent. of the university extension courses of the English universities were in the sciences.

This marked decline in science classes for adults has caused serious concern, if not alarm, on the part of educators, sociologists, philosophers and publicists, as well as among leading scientists. Similar concern has manifested itself in England, where a committee of the British Association for the Advancement of Science reported on the problem at the Leicester meeting last September (1933). This solicitude has been justified in various ways; but, with the exception of some five or six out of about 200, all scientists and educators interviewed in the course of a study made in the winter of 1933–34 agreed substantially that there is a real need for the wider diffusion of scientific knowledge and scientific attitudes among the population at large.

Living in an age that is being modified by science calls for an education which equips one to meet a variety of changes. Unlike much of the traditional education, that which is now needed can not consist merely of accepted knowledge or of specific skills. Both what we know about the world and about ourselves and

the procedures by which the necessary work is carried on are being altered by the impact of science. It is impossible to foresee these changes in detail, and preparatory education involves therefore not so much definite beliefs and techniques as a certain attitude—a readiness to consider the new without prejudice and to reexamine what has been, a constant requestioning of old values, a retesting of old procedures.

Science as a method of dealing with ever new problems or with old problems in new settings must be democratized, must be removed from the exclusive custody of specialists, must be assimilated by the entire population and made part of the common life.

The decline of science in adult education, as indicated by the figures regarding classes and extension courses, may, however, be apparent only, not real. The expansion of the common schools to reach nearly the entire population and the extension of the high-school facilities until about half of the boys and girls of high-school age are actually enrolled have resulted in making the adult population increasingly able to rely upon the printed word for much of the information and enlightenment that in the past had to come by way of the living voice. If in some cases poor instruction has made some of the grown-up boys and girls indifferent to science or satisfied that they had finished the subject, in other cases the school instruction has made unnecessary adult classes in the elements of science. A parallel decline over a generation in the prominence of mechanics institutes or of night classes for teaching adults the art of reading may indicate not a loss, but a substantial gain, in cultural development.

When every person of voting age will have had the equivalent of an introductory course in general science during the regular schooling, there will be no occasion for adult classes in elementary science. Similarly, when the daily news brings reports of "findings" in terms that are generally intelligible and that for the time being satisfy the curiosities, there may be no more occasion for special classes in science for adults than there is now occasion for special classes in grammar and rhetoric for college graduates.

It is not to be assumed that such decline as has taken place is all accounted for or all compensated for by the changes in educational procedures and opportunities that have been suggested. There is indeed evidence that the situation has been affected by other factors. In many cases opportunities and facilities are inadequate for existing needs and demands. In other cases opportunities are withheld because those in charge of adult education programs themselves lack understanding and appreciation of science in modern life. Scientifically trained men and women are under such pressure to continue research or to teach in academic institutions that there is little encouragement for competent scientists to attend to work with adults. There is also the competitive demand upon the limited free time: the "hunger for recreation is far from satisfied." And there is further the competition of other educational or cultural interests. Increasingly since the world war, and especially during the past four or five years, the serious reflection and inquiry of adults are turning to questions of economics, social relations, political and international relations and practises. The controversies, which themselves stimulate interest in serious study, have less and less to do with reconciling science with various theologies, and more and more to do with reconciling science as embodied in the new technologies with various assumptions as to the good life in an industrial society.

One further change, which is itself the outcome of the diffusion and advancement of science, may have a bearing here. A generation ago the scientists

generally felt the evangelical urge to share with others the benefits that they had gained from preoccupation with scientific pursuits and reflection. While statesmen, whether benevolent or despotic, and reformers feel that people need to be educated, the scientist feels that his own findings and thinkings are important for all. It was during the second half of the past century that this spirit reached its widest expansion. Tyndall and Huxley in England and Haeckel on the continent were the very embodiments of this spirit. But one of the consequences of more study and reflection by scientists was the weakening of the evangelical urge. A philosophy that starts out with doubts and ends with tentative conclusions and that raises so many additional questions as it moves along can not address itself very convincingly to the promulgation of a new gospel. Thus it happens that while there is a tremendous increase in systematic propaganda of all sorts, and while the individual evangelist can still get public attention, the furthering of science by such methods has steadily declined. Moreover, the scientists as a group are no longer under the same compulsion to urge upon the public an appreciation of science, nor (until quite recently because of the identification of "unemployment" with excessive technological efficiency) do the scientists feel so much the need of defending science against general hostility. Science has indeed come to be taken for granted; the scientist feels relatively secure; and perhaps at the same time the public feels an unwarranted reliance upon some mystic capacity in "science" to solve all our problems.

The popularization of science in the past, and down to this very day, may conceivably operate to the injury of science. It is not merely, as some scientists seem to fear, that the oversimplification of the specialist's ideas makes the specialist out to be rather simple-minded or exposes him to foolish discussion by the ignorant. The danger lies in reducing science to a modern form of magic. Much of the popular science, in newspapers and in other media, is trivial and misleading. It arouses awe and admiration perhaps, but also credulity of the blindest sort. There is something of condescension in the extravagant emphasis upon the spectacular. Science has produced startling results by bringing about action through space. You can hear Byrd's voice in the comfort of your home while the explorer is buried in the snows thousands of miles away. You can spring the front door of your exposition open by a beam of light from the star Arcturus, which is even farther away. Science has enabled us to see right through the deceptions and illusions that unscrupulous mountebanks in the past imposed upon the gullible public. It exposed spiritual mediums and forged signatures and defective armor. And it is in turn able to perform miracles far more wonderful than any dreamt of in the past. It not only makes bread more abundant, at least on the average, but it supplies an interesting circus and reveals hidden mysteries.

Thus science has been "sold" to the multitudes, and the public has become favorably disposed toward science. But through the familiarizing of the public with the terms and symbols that suggest the marvelous, this public becomes conditioned to further exploitation of its residual ignorance: the way is paved for quacks and frauds who can reenforce their blandishments with the magic words supplied by science. The mere selling of science may thus become a disservice: familiarizing the public with new words may do more harm than good.

Through the zealous dissemination of such science we have all become familiar with vitamins and ultra-violet rays, with endocrines and hormones, with colloids and enzymes. To be sure, we do not always know what these things mean;

but we are nearly all confident that they imply something very profound and very important.

The newspaper and other popularizations supplement the news with advertising. The whole population becomes aware of the virtues of toasting for ice-cream or shaving cream: heads of great industries and great educational institutions applaud the initiative that calls upon science to toast its products with x-rays in a manner that makes everybody feel that he must have toasted lead-pencils. We absorb the gospel of stream-lined tooth-brushes and radio cabinets. When everything else fails, we are converted to the merits of wrapping each doughnut in its individual capsule of Cellophane.

Much of the popularization of science for adults is closely related to technical or vocational instruction. It informs the public of better ways of doing things. It is a manifestation of that phase of science which Francis Bacon glorified as giving man power. It represents usable knowledge. But in the process of diffusion, no distinction is made between useful tricks facilitating and enriching the routine of life and propaganda for the acceptance of a special doctrine or for the sale of surplus stocks of superfluities. The ordinary reader is unable to check what comes to him. He does not know whether it is the honest finding or thinking of disinterested scientists or a fragmentary and deliberately colored "truth" separated from its setting in order to produce a desired impression in accord with a sales policy or a partisan assault.

This distinction we recognize to be important when we discover ourselves to be the victims of misrepresentation, or when, with a safe perspective, we can see the process operating at a distance. We smile with complacent superiority when we read of some backward nation "using statistics as an instrument of state policy." But the statistics for which we ourselves reach out to serve our purposes do not carry on the surface any certification as to their authenticity or reliability; and certainly the "interpretations" that come with the statistics are not easily tested, even by very intelligent men and women. Almost any kinds of statistics can be had to order—to "prove" that prices are going up or down, that unemployment is increasing or decreasing, that there is or is not a "business cycle." It is no wonder that some at least are suspicious of statisticians. But in a similar way it is possible to put out "evidence" from the chemical laboratory or the engineering or psychological laboratory, and so to divert us into buying our foods or cosmetics and fabrics and cigarettes from one set of producers and purveyors rather than another, under the charm of "science says." By the judicious use of scientific jargon a whole city can be made to insist upon having the bread that comes in pink wrappers.

If science as a mode of dealing with certain kinds of problems is to be effectively assimilated, it would be necessary to supplement the journalistic functions of the newspapers and the popular lecture and the radio broadcast with forms of comment that will bring out the cultural and philosophical implications of the "news" in science, as distinguished from the economic and technical applications—and especially from the commercial and industrial misapplications.

Of course every informed person knows that advertising exploits our ignorance, our prejudices, our fears, our vanities, our ambitions, our anxieties, our solicitudes for those we love. What we do not all know is that we are similarly misled by what passes for honest-to-goodness news and reports of what the scientists are doing. This is not to say that we are being deliberately misinformed. It means only that with a progressive division of labor which has become accelerated in modern times

largely because of the very nature of science, it has become increasingly difficult for the layman to understand what the scientist is thinking, just as it has become increasingly difficult for the scientist to address himself intelligibly to the general public.

For this failure in mutual understanding no party is to blame. The nature of language, which is essential to man's intellectual growth, is itself a source of the difficulty. In fact, many intelligent, educated adults, who have not themselves given much attention to the study of scientific subjects, entertain a curious resentment against the science guild because the latter does not express itself in common language that ordinary folks can understand. In extreme cases there is a suspicion that scientists develop their own jargon simply to keep their secrets to themselves. We still find people who assume seriously and as a matter of course that physicians' prescriptions are written in Latin only to enable the druggist to charge an excessive price for something that could as well be bought for a few cents by giving the "common name." It is no doubt true that in many cases a common name could be used where a technical term is used, but, generally speaking, it is essential to the growth of science that new terms be invented and that familiar terms be restricted in their meaning for technical purposes. It is unfortunate that this irritates the layman, that it obstructs his approach to desired knowledge and understanding, that it tends to make the speech of the specialist mysterious and esoteric, and indeed often tempts the scientist to a certain pedantry and exclusiveness. It is not true, however, that "plain language" could be used just as well. Nor is it true that the specialized use of common terms can be avoided—except by the substitution of new technical terms which would be perhaps just as confusing. It is not necessary to defend the scientists for this elaboration of their own jargon. This process is absolutely essential to clear thinking at any level and in any field of human activity in which communication is required, in sports and commerce no less than in electrotechnics and metaphysics. Similarly, the arbitrary restriction of a familiar term to a specific meaning is to be found in the church and in the kitchen, in every area of occupation or organized relationships. In the very nursery "common" words are turned into pet names and restricted to familial functions.

The language of the specialists is thus of necessity a foreign language to the lay public. But as strange words become familiar, and especially as familiar words become embodied in this strange language, there is the constant danger of the reader or listener jumping to conclusions, drawing inferences, forming conceptions that are not within the intent of the speaker or writer. The progressive separation of the scientist's concerns and thoughts from those of the layman, coupled with the immediate relevance of many of the scientist's doings in our daily lives, has made it increasingly necessary to develop intermediaries who will translate the foreign language of the scientist, as nearly as may be, into our common language and thought.

It is not to be expected that the thought of the scientist can be converted into common thought; but certainly we must try to guard against the degradation of the common thought by divorcing it from science, the modern source of authority in so much of our common life. The diffusion of findings, the meanings, the methods of science can make valuable contributions to the individual's interests and concerns, as in improving his health and the management of his practical affairs or as in providing him with a healthful and satisfying and growing hobby. Science may advance the common cultural interests, as in

shifting authority from traditional beliefs and institutions to proven experts, or as in eliminating superstitions and fears, or in broadening the sympathies and tolerances of the members of a heterogeneous population. A general understanding and appreciation of scientific principles and methods may also advance the civic and social interests by directing more critical and independent thinking to the common problems.

Throughout the ages man has refused to accept the restrictions implied in his thin skin and tender muscles. He has been well called nature's recalcitrant son —a rebellious Lucifer, the beneficiary of Prometheus and his stolen flame. He has circumvented the orderly course of events that threatened to destroy him, by resorting to knowledge which strengthened his arms and lengthened his legs. We value science because it means power. It is the ultimate attainment of man in his struggle with the obscure forces of his environment, whether "natural" or "artificial," whether "material" or "spiritual." Science is the more or less systematic pursuit of knowledge which enables man to do as he has always done, only more so, whatever he wishes to do, more rapidly, more energetically. But with the gains come certain disadvantages.

For one thing, science eliminates individual differences. As Carlyle said of gunpowder, it makes all men of like stature. Pulling the trigger does not call for great physique. Increasingly the same degradation of superiority has followed in the wake of scientific advancement. If science enables a Hitler or a Roosevelt to be heard round the world, it enables also a Caspar Milquetoast to carry his whisper far beyond the reach of his voice. It enables ordinary eyes to see the moons of Jupiter or the granules in the tiniest microbes. Synthetic silk, Dean Ford reminds us, makes Judy O'Grady and the Colonel's lady sisters *over* the skin. By devising delicate gauges and automatic mechanisms man's ingenuity and science have enabled him to concentrate tremendous energies into a small area and to control that energy through trivial movements of levers and buttons—which a simple-minded child can manipulate as effectively as a wise and powerful giant. In these ways science has made us so much alike that for certain purposes we have lost our individualities: we have become numbers on the time-keeper's register, so many hands for industry, so many customers for commerce, so many heads per acre for the statistician.

But for another thing, science accentuates individual differences. If we can all see equally well the moons of Jupiter, the imagination of an Eddington or a Shapley can see what was far beyond Galilei or Kepler. If we can all see microbes in a high-school microscope, only a Pasteur or an Ehrlich can get new meanings out of what is now become universally patent. If everybody's voice can carry equally well around the world, he who has something important to say can now get attention as never before. The individuals of genius or creativeness have now greater opportunity than ever. Science enables them not only to magnify all man's doings; through it they have actually created what never was on land or sea. There are new colors and drugs, not to be found in a state of nature; there are new fabrics and plastics and alloys; there are new plants and animals such as the field taxonomist never saw. Through science we have accelerated all our processes. The evolution of species has been condensed into a lifetime. We can now ripen whiskey in a few hours and demolish a cathedral, yes, a whole city, in a few seconds.

Now everybody knows all this. Nobody can overlook the achievements of science in terms of total production or average output. This is not then in praise of science; nor yet in reproach. It is only in the way of emphasizing the

inherent danger of placing so powerful a weapon in the hands of immature, awkward, irresponsible men and women.

While science has filled man's surroundings with millions of exciting novelties, and has lengthened his span of years, it has also threatened to deplete his life of all meaning. The dissemination of science as "news" is on the increase, but the material offered the public is usually without any indication of its significance, as related either to the underlying problems and historical developments or to the interpretation of conditions and phenomena.

Some of the philosophical implications of scientific methods and specific findings have long been generally recognized. For example, there is little occasion today to dispute Galilei's removal of the earth from the center of the universe. Very few people who have had time to get their bearings are troubled by the doctrine that species are mutable, including the human species. The age of the earth is stubbornly restricted to some five thousand odd years only among the most benighted, as if it had any essential relation to religion or the conduct of life. More and more men and women are discovering the futility of disputing verifiable facts; and of speculating where facts are ascertainable. Opinion is being pushed off the throne of personal privilege. We are finding a new source of authority in the expert, and a new valuation of expertness.

The general tendency among those who have given some thought to the place of science in adult education is: (1) To value increasingly the hobby interest or the personal curiosity motive; (2) to demand more participation or activity on the part of the "learners," as against purely verbal instruction—telling or showing on the part of the teachers; (3) to lay more emphasis upon interpretational as against informational effort; (4) to attach increasing importance to cultural outlook and the development of appreciations and to systematic consideration of the social implications of the domination of science in our lives.

We are finding more and more appreciation of scientific procedure as a mode of looking at the problems with which life confronts us, a procedure that transcends in value the solution of industrial problems. But the scientists themselves are finding, often to their chagrin, that they have not consistently valued science outside their own fields. They have resembled other human beings in retaining infantile fantasies as to the good and true in many realms that had been overturned by other scientists. The distinguished chemist or physicist may still be found to speak solemnly on current problems—that is, other than chemical or physical problems—in the language and the concepts which he acquired in his undergraduate days. He relies as he did in his youth upon the authority of the great person—the statesman, perhaps, or the successful business man or the editor of his family's favorite newspaper—while he himself is constantly striving to overthrow authorities in the area of his own expertness.

There is reason to believe that large numbers of high-school and college graduates (including professionally trained men and women whose occupations rest upon the application of scientific principles) are quite as much in need of direct help and guidance in "keeping up with science," as are those who are admittedly without education in science. This problem is at any rate not restricted to the "under-privileged." Whatever value there may be in getting some people to acquire scientific attitudes and to master scientific methods of dealing with problems must be significant for all, within the limits of individual capacity. For keeping up with science means a great variety of activities. For the specialist, whether a professional or

an amateur, it is necessary to know what his fellow-specialists are doing. For the ordinary citizen it is not very important that a new kind of orchid or a new variety of flea has been discovered; or that an ancient species has been split up into three. It is not very important even that the atomic weight of one of the elements has been redetermined with the result of altering by two points the figure in the third decimal place. Increasingly science is important as it modifies our outlook or enriches our appreciations, whether of the things of nature or of the doings of man. There is as much thrill—for those who care for such things—in a neat demonstration or a refinement of deduction as there is in a fine piece of workmanship or in a beautiful design in painting or music, or a moving poem.

To know what problems preoccupy the scientist may be more significant than to know what he has found out. To get from the growth of science a more objective attitude toward those who are not altogether like ourselves may be worth more than being able to increase our exports and imports of material goods.

Finally, the concern of adults with science must lead to a new and searching consideration of the implications for social and political and economic life of the human process which we call science —a vast spiritual cooperation that is basically without guile or ulterior motive, that is for its devotees a truly religious experience, and that can continue only as thought everywhere is liberated—that is, as human beings everywhere convert the practical contributions of science into a means of material security in order to give the adventurous spirit of man broader scope and more substantial support.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

THE FORGOTTEN AGE OF CHILDHOOD

By Dr. P. H. FURFEY

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THE psychology of adolescence has long interested students of childhood. More recently there has been a great deal of excellent research on the infant and the preschool child. The intervening period, however, say, the period from about six to fourteen years, has even now been very inadequately studied. So little is known with scientific accuracy about this period that we may appropriately term it "the forgotten age of childhood."

It seems strange that this age period should have been neglected by scientists; for it is a time of important and dramatic changes. Between the ages of six and fourteen the child doubles his weight and increases about one third in height. Educationally, this period practically bridges the gap between the kindergarten and the senior high school. Socially, it extends from the dependency of the six-year-old to within a couple of years of the age when marriage and full-time employment are legal in some jurisdictions.

Perhaps the deepest significance of this age lies in this last fact of socialization. For it is here that the child learns the principles of that social cooperation upon which any successful democracy must be based. The six-year-old is an individualist. He has not learned to sacrifice his own individuality, except unwillingly, for the good of the group. But at fourteen the child knows that the success of the social whole may be more important than his own success. In more concrete terms, team games and club activities have become possible at age fourteen. They were impossible at age six.

Since this is true, we have good reason to be interested in this forgotten age of childhood. As educators, as parents, as socially-minded citizens, we have the task of training our children into a worthy citizenship. May I suggest that this task involves the forgotten age of childhood to a much greater extent than we have realized in the past?

To illustrate the progressive socialization of the child during the grammar-school age, I should like to tell you about some growth studies made by some of my graduate students and myself. We tried to get a series of cross sections of child life by studying boys and girls at the ages of six, eight, ten, twelve and fourteen. We interviewed each child within a few days of his birthday. We also used, as far as possible, mental tests, physical examinations, home visits and interviews with teachers and others who knew the child in question. The result was a series of case studies picturing child development at various stages throughout the grammar-school period.

One index of socialization is the gradual loss of shyness in dealing with adults. About one fifth of the six-year-old children were so shy that they refused to answer at all when addressed or else they answered in monosyllables or in a very low tone or even cried or ran away. At age fourteen, of course, shy-

ness of this extreme variety had disappeared entirely. Some of the girls particularly showed at this age an almost adult self-possession.

The growth of social control shows a similar rapid growth. Both the six-year-old and the fourteen-year-old yield obedience to the laws and customs of our civilized society, but the obedience is of a different sort. The six-year-old is likely to yield unquestioning obedience to any adult who speaks to him authoritatively. His life is regulated for him largely by the adults of his own household. At twelve, and particularly at fourteen, the child's obedience rests on a more rational basis. Before he obeys, he wants to know why he should obey. At this time also there is an increasing independence of home authority both in the case of boys and of girls. Companions of their own age assume a growing importance, and a new loyalty to these companions begins to modify the formerly almost complete dependence on home.

Not only is the child more dependent on his companions as he grows older, but the type of companionship changes. One very interesting index of this fact is the changing relation between the sexes. Of the boys studied at the age of six, 81 per cent. admitted that they played with girls. Six years later this proportion had sunk to the minimum of 20 per cent. At age fourteen it has begun to rise again with the approach of adolescence. There is, then, a sort of a neutral period in the midst of the grammar-school age when companionship between the sexes is very uncommon. Before this neutral period, the young children of both sexes play more or less indifferently with each other. After this neutral period adolescent boys and girls are beginning to adopt the adult relationship between the sexes. If we care to view the neutral period teleologically we may think of it as a period of preparation during which the sexes separate to prepare for the responsibilities of parenthood.

Play is another index of the progressive socialization which we have been discussing. Perhaps the most conspicuous feature of the play of the six-year-old is what is called "dramatic play," that is to say, play which contains an element of make-believe. At the age of six, 100 per cent. both of the boys and of the girls enjoyed dramatic play of some sort. For the most part this consisted in the imitation of some sort of adult activity. Most of these adult activities were those which the children had actually observed. Thus, for example, the girls played being mothers or teachers, while the boys imitated policemen, firemen or mechanics. Less common, and more characteristic of slightly older children, was the imitation of real activities which lay outside the child's actual range of observation. For example, boys imitated pirates, cowboys or Indians. Least common was dramatic play involving the imitation of imaginary beings, such as Santa Claus or of animals.

By the age of ten and twelve dramatic play had declined enormously in popularity. Certain special types, however, retained their hold upon the growing child. Boys continued to play with electric trains and with such construction sets as Meccano and Erector. Among the girls the two types of dramatic play which survived to this age were the making of dresses for dolls and dressing up in adults' clothing. For this latter activity a pair of high-heeled shoes seemed to be an absolute essential. With the aid of these and an old dress of their mother or elder sister, the girls enjoyed the temporary thrill of imagined adulthood.

Parallel with dramatic play but out-

lasting it chronologically was an interest in active, outdoor games. This interest showed itself at the younger ages in the form of rather unorganized free play. Thus the girls of this age enjoyed tag, roller skates, jump rope and similar activities, while the boys enjoyed rudimentary play with baseballs, footballs and basketballs, which, however, never took the form of the real team games of these names. The boys also skated on roller skates, played tag, ran, climbed and fought good-naturedly. By the age of ten the competitive element seemed to become more and more prominent in such activities.

Somewhere around ten or twelve a new type of play appeared and one of the very greatest importance for the social development of the child. I refer to the appearance of team games and club activities. This tendency is discoverable in both sexes but appears most strikingly in boys with their suddenly awakened enthusiasm for the standard team games—baseball, football, basketball, and the rest. The new interest in these games means something of tremendous social significance. It means that the boy has suddenly realized that the group may be more important than the individual. Hitherto his ambition has been bounded by the hope that he could himself do something striking and dramatic. He personally must be the center of attention. Now, however, he learns the new thrill of group success. He is content to play right field and enjoy a new sort of pleasure when his pitcher strikes out three men in a row.

The same changed psychology is shown by the new adaptability of both sexes to club life. The great national clubs, such as the Boy Scouts, the Girl Scouts, the Camp Fire Girls, appeal, at least in their junior programs, to children from the age of ten up. The sense of belonging, the thrill that comes from being a part of a social unity, makes this club life possible, where it was not possible a year or two earlier.

With the dawning of this social sense the child learns to be a leader or, what is no less important, to be a good follower. He learns the give-and-take of social cooperation. He learns that his individual life may be less important than the life of the group to which he belongs. The girls' group, the boys' team or gang is the first school of civics, the firm basis of a successful democracy.

The child emerges from the grammar-school age changed in many respects. He has lost some of the dreamy romanticism of the age of dramatic play and has acquired a new realism, a changed attitude illustrated by one little girl, who, when asked her vocational ambitions, replied somewhat wistfully, "I'd like to be a dancer, but I guess I'll be a stenographer."

The boy or girl of fourteen stands on the threshold of adult life. Soon adolescence will precipitate the child into a bewildering world of strange, mature emotion. He will be called upon to make decisions upon which his subsequent happiness may depend. He will be called upon to take his place in an unaccustomed adult world. We shall find him, as an adolescent, difficult to control. But if the socializing process of the grammar-school age has been well accomplished we shall have no reason for anxiety. For this is the key to a successful adolescence, just as the latter is the key to well-adjusted adulthood.

I close with the hope that the grammar-school age may cease to be the forgotten age of childhood. I feel that a better understanding of this significant, important and interesting age period will be the key to the solution of many pressing problems of individual and social conduct.

STELLAR GUESTS

By Dr. F. ZWICKY
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STARS to the ancients were symbols of the eternal and unchangeable. From observations with the unaided eye our ancestors concluded that stars were fixed objects patched on a celestial sphere, objects which did not show any signs of physical changes in time.

To-day, from observations with powerful telescopes, we know that the vast spaces beyond the sun and its planets, and the stars which inhabit these spaces, possess a life and a history all their own. One of the major problems of modern astronomy is to answer the basic questions of the life and history—namely, the origin, existence and death of stars.

Suspicions that stars are not, after all, eternal and unchangeable must have occurred to many a keen mind among the philosophers of the past. Perhaps the first to voice this suspicion clearly was Tycho Brahe (1546–1601), son of a Swedish nobleman and one of the most eminent astronomers of all time. Tycho's suspicion was specifically aroused by the appearance of a strange new star in the constellation of Cassiopeia. This star flared up on November 7, 1572. It outshone all the others for several weeks and then gradually waned to such dimness that not even with the largest of modern telescopes can astronomers discover its remains. At its maximum the new star was at least as bright as Venus at its best, so that it could be seen in daytime. So sudden and bewildering was its appearance that Tycho hardly knew whether to trust his own eyes. His impressions are well described by his words that "It was a miracle, even the greatest of all miracles that have occurred in the whole range of nature since the beginning of the world, or one certainly to be classed with those attested by Holy Oracles, the staying of the sun in its course in answer to the prayers of Joshuah and the darkening of the sun's face at the time of Crucifixion."

Fortunately, Tycho Brahe was not entirely overcome by the miracle, but settled down to undertake measurements. The accuracy of Tycho's determination of angles is about one minute of arc (the 5,400th part of a right angle); an astounding accomplishment if we remember that the telescope had not yet been invented. As the new star of 1572 showed no proper motion, Tycho concluded that it belonged to the fixed stars, and he emphatically stated that the world beyond the planets could not by any means be unchangeable, as was then generally assumed. This recognition, as I have said before, makes Tycho the father of our modern ideas on the evolution of the universe.

Let us now examine what we know to-day about stars of the type which Tycho saw. With the aid of large telescopes, we have learned that stars are self-luminous hot bodies, ranging in surface temperature from about 2,000° to 100,000° Centigrade. Most of them are very similar to our sun, which has a surface temperature of about 6,000° Centigrade and a mass some 300,000 times that of the earth. Stars are not entirely distributed at random throughout the universe. They are rather bunched in what are called island universes or nebulae. Every nebula contains something like a billion stars. All the stars of the Milky Way form such a nebula, of which our own sun and its neighboring stars are quite humble members. This, our own galaxy or nebula, is approximately a watch-shaped affair whose center lies 30,000 light years from the earth in the direction of the constellation

of Sagittarius. Another island universe, in fact, our nearest big neighbor among extragalactic objects, is the great nebula in the constellation of Andromeda. Both our own galaxy and the nebula in Andromeda have diameters of the somewhat unimaginable size of 50,000 light years. That is, it takes light, which travels at a speed of 186,000 miles a second, about 50,000 years to traverse a nebula from one end to another. The distance from us to Andromeda is still greater, namely, about 900,000 light years. As far as we can tell from observations with the hundred-inch telescope, nebulae, unlike stars, are distributed at random up to distances of about 600 million light years.

Coming back to stars, we observe that some of them, once in a long while, become capricious, and for reasons as yet unknown increase their brightness 10,000 fold or more, at the same time spouting hot gaseous clouds into interstellar space at speeds of as much as 1,500 miles/sec. Such stars are called *novae*.

There are really two types of novae, or stellar guests, as the Chinese call them. The first type, which we designate as common novae, waxes to a maximum brightness of about 20,000 times that of the sun. Perhaps twenty common novae per year flash up in the Milky Way, and an equal number per year has been observed by Dr. Hubble, of the Mt. Wilson Observatory, in the great nebula in Andromeda.

The second class of stellar guests is made up of so-called super-novae. Super-novae are much more tempestuous than common novae. Within a few hours they may become as bright as the whole nebula in which they originate. For several weeks they shine, per unit time, as much light into space as a hundred million suns put together. It is fair to say that they represent the most colossal catastrophes of matter which man has ever been privileged to witness. There are good reasons for the assumption that Tycho's star of 1572 was such a super-nova. The study of these stars is not an easy matter. They are very exclusive, making their appearance in a given nebula only once in several centuries. Therefore, unless we are very, very lucky we have little chance to observe one of these stellar guests in the Milky Way during our lifetime.

Our knowledge of super-novae in the Milky Way is derived entirely from ancient records. The voluminous books of the Chinese astronomers are particularly illuminating. Most of the observations of novae occur in the so-called encyclopedia Wen-Hieng-Tong-Kao, which was translated by the French linguist, Biot, about a hundred years ago. In this encyclopedia we read that new stars or novae appeared in 134 B.C., 123 A.D., 173 A.D., etc. The star of 134 B.C. was also observed by the great Greek astronomer Hipparchus of Nicaea, which proves that the Chinese astronomers were not just blowing bubbles. The Chinese observations were recorded in terms which to us sound amusing. For instance, we read about the nova in 173 A.D. that

> In the second year of the epoch Ching Ping, the tenth moon, on the day of Kwei Hae a strange star appeared in the middle of Nan Mun (the "southern gate," which is one of the 31 constellations into which the Chinese subdivided the sky). It was like a large bamboo mat (the observer means that the star was scintillating and looked hazy). It displayed all the five colors, both pleasing and otherwise (red is pleasing, white is not, to the Chinese). It gradually lessened. In the sixth moon of the succeeding year it disappeared.

Fortunately, the Chinese observations as to where in the sky the stellar guests flared up, what their appearance was and how long they lasted are quite accurate. The Swedish astronomer Lundmark[1] has worked on these records and concluded that most of the novae have

[1] K. Lundmark, *Publications of the Astronomical Society of the Pacific*, 33: 225, 1921, and Lund Observatory Circular No. 8, December 31, 1932.

been located in and around the constellation of Sagittarius. This is exactly what one should expect, as the denseness of stars in this direction is by far the greatest. To-day we know that the great star clouds in Sagittarius are at an approximate distance of 25,000 light years. From this fact and the recorded apparent brightness of the Chinese stellar guests Lundmark was able to compute their absolute brightness, which came to be about that of a hundred million suns put together. Many of the new stars described by the Chinese therefore seem to have been super-novae.

With the large telescopes we are not confined to observations in our own galaxy, and our chances of finding super-novae are greatly increased. Consequently, about fifteen super-novae have been recorded during the last fifty years. The most conspicuous one appeared in Andromeda in 1885. However, the astronomers who discovered these novae in distant nebulae did not know what kind of tremendous objects they were dealing with. This is due to the fact that only in the last decade, thanks to the work of Dr. Hubble and others at the Mt. Wilson Observatory, has it been proven beyond reasonable doubt that nebulae are island universes which consist of billions of stars.[2] In addition the distances of many nebulae were determined. Hubble found for instance that the five hundred galaxies which form the great cluster of nebulae in Virgo are about seven million light years distant. As some of the novae were as bright as the whole nebula in which they appeared, it follows that their absolute brightness must have been comparable to that of a hundred million stars. This result and Lundmark's conclusions concerning the novae which were recorded by the Chinese are in surprisingly good agreement. Dr. W. Baade of the Mt. Wilson Observatory and I last year called the attention of scientists to these conclusions.[3] Working up all the material which was available on temporary stars we arrived at the following tentative views:

(1) Super-novae are initially quite ordinary stars.
(2) For reasons as yet unknown these stars explode violently and send into space, during a few weeks, an amount of radiation which corresponds to the complete annihilation of a great part of the star's mass.
(3) Super-novae, perhaps, are the grand finale of stars, marking their transition from their ordinary state of existence characterized by a relatively low density into celestial bodies of extremely high density and small diameter.
(4) Cosmic rays originate mainly in super-novae.

Just how we arrived at these conclusions can not be discussed here. However, it seems clear that further investigations on super-novae will no doubt be extremely fruitful.

From what I have said before, it is safe to conclude that in a given galaxy at least one super-nova may be expected to flare up in a thousand years. If, therefore, we could observe a thousand galaxies continually we should find about one super-nova per year. Actually the most convenient place in the sky to look for super-novae is the great cluster of galaxies in the constellation of Virgo. As this cluster contains about 500 galaxies we hope to find on the average one super-nova in two years. The Virgo cluster, although seven million light years distant, can be photographed with quite small telescopes. In fact, the large telescopes are in this respect rather

[2] In this connection reference to the extensive investigations on the nature of extra-galactic nebulae, which K. Lundmark took up in 1920, should not be omitted.

[3] W. Baade and F. Zwicky, *Proceedings of the National Academy of Sciences*, 20: 254, 1934, and 20: 259, 1934, and *Physical Review*, 46: 76, 1934.

useless, as their fields are too restricted. Good photographic objectives of four- to five-inch aperture allow a satisfactory survey of these nebulae. Amateur astronomers quite often command adequate means for such surveys. Once a super-nova is found, the big telescopes will do the rest and furnish the much desired detailed information about these gigantic explosions of stars.

In addition we intend to search for the remains of super-novae which have flared up in the past. (If these remains are, as we think, *neutron stars* they will be very inconspicuous objects in the sky and will be reached only with the largest telescopes).

In conclusion, I emphasize again that the investigations of super-novae are in their infancy. However, already enough facts are available to suggest that further studies on super-novae will lead to important information regarding the constitution and the evolution of stars. Future observations on temporary stars also may hold the key to the riddle of the cosmic rays.

All the knowledge about super-novae which we possess to-day is derived from past records. The Chinese, the Persians and the Greeks have furnished us valuable data. Tycho Brahe, Kepler, Thomas Digges,[4] Galilei, Newton, and many others who towered above the Middle Ages like the spires of the Gothic cathedrals, first formulated mathematically some of the fundamental laws which govern the happenings in the universe and which enable us to-day to investigate the rôle played by temporary stars in the eternal evolutionary processes.

[4] As the work of Thomas Digges is perhaps the least known I refer to the recent publication in the Huntington Library Bulletin V, April, 1934, by F. R. Johnson and S. V. Larkey on "Thomas Digges, the Copernican System, and the Idea of the Infinity of the Universe in 1576."

Let us also not forget the astronomers of the last generation who for the first time in history had at their command two mighty aids, the spectroscope and the photographic plate. Photographic records which these men made in Pulkowa in Russia, Kônigstuhl above Heidelberg in Germany and other observatories are still available, and it remained only for Dr. Baade to perceive their value in the study of super-novae. Such cooperation, transcending all barriers of time, race and creed, has alone made possible the consistent advance of scientific thought. In conclusion, I should like to point out that since, as far as we know, any star may become a super-nova, the theory gives us a new idea of the possible nature of the end of the earth. Should our own sun suddenly explode, this friendly planet would shortly be nothing but a cloud of hot gases drifting in space. Lest any of my hearers become alarmed, however, let me add that until we know more concerning the origin of stellar guests, the alarmists are still in the position of the lady who anxiously asked a famous astronomer, "How long, professor, did you say the sun would last?" His answer was, "A few billion years at least." The lady exclaimed, "Thank heaven, I thought it was only a million years."

After this manuscript had been prepared and sent off, Nova Herculis was discovered. The spectrum and light curve of this temporary star indicate that it falls into the class of the common novae. Professor Kolhörster in Berlin has just announced that Nova Herculis, at maximum, increased the intensity of the cosmic rays arriving on the earth by 2 per cent. This observation, if correct, is the first *direct* proof of the theory that cosmic rays originate in temporary stars, which Dr. Baade and I have suggested a year ago.[5]

[5] *Op. cit.*

THE MAGIC AGE OF ALLOYS

By A. B. PARSONS

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If I should bluntly declare that the world had made more progress in applied science and invention in the last thirty-five years than in the thirty-five *thousand* years immediately preceding, most of you would frankly charge me with gross exaggeration. But, as a matter of fact, the truth of the statement can be shown.

If I were to tell you that the biggest factor in this twentieth century progress is the amazing development in the arts of making and using alloys you would again be skeptical. And this time your skepticism would be justified, for the following simple reason: This material world of ours is so complex; each achievement is so dependent on a dozen others that no one branch of science or technology can fairly be singled out as making the preeminent contribution to progress. At the very least, however, it can be said truthfully that no one has a better claim to being the major contributor than the alloy metallurgist and the metallurgical engineer.

Useful manufactures in times of antiquity consisted principally of weapons of war such as spear-heads, arrow-heads and battle axes; and tools of peaceful industry such as knives, hammers and chisels. First, these were fashioned of stone—in the Stone Age; later of copper and bronze; and still later, beginning a few hundred years before the Christian era, the same implements were made of iron—in the Iron Age. History shows that industrial progress has kept step with improvements in the characteristic mineral material of which were made the tools, the weapons and the structures of successive epochs.

Some may contend that the Iron Age is still with us. Admittedly, lots of iron and plain carbon steel will be used in the future. But just as surely they are gradually being pushed into the background. Alloys have the spotlight; the magic age of alloys has arrived. You who listen will be surprised to learn how many of the seeming miracles of our modern everyday life depend, in unsuspected ways, on machines and tools that could not be made to perform as they do except for alloys.

Just what is an alloy? Simply stated, an alloy is a mixture or, more exactly, an amalgamation of two or more metals produced by cooling a melt containing the various ingredients in the desired proportions. But, like the art of baking good cake, for instance, the art of making good alloys requires more than throwing into a pot the right quantities of various metals and pouring the melted mixture into a mold to cool and solidify. A great deal depends on the way the constituents are added, the temperatures reached, the method of cooling; and, in fact, on the way the alloyed metal is treated after it is once cast.

Most metals can be alloyed with any others, and in almost any proportions. Sometimes an alloy consists of definite proportions of as many as six or eight metals. One light alloy, used for parts of airplane engines, contains copper, nickel, iron, silicon, magnesium and cerium, all totaling 8 per cent.; the other 92 per cent. being aluminum. The principal metals in the order of the quantity normally used by the world are, first and foremost, iron; then copper, lead, zinc, aluminum and tin. In a third group are manganese, nickel, molybdenum, tungsten, silicon, vanadium, chromium and cobalt; used, for the most part, to alloy with iron or steel. Fourth, is the pre-

cious metal group: gold, silver, platinum, palladium and the metals associated in nature with the latter two.

What is the purpose of making alloys? Simply this: to get a metallic material that has desired qualities or characteristics that no single metal possesses in the necessary degree. Fifty years ago a simple metal like iron, copper, lead or tin met the modest requirements of the manufacturer or builder. He wanted moderate hardness, strength, plasticity and durability.

To-day the demands are ever so much more complex and exacting. As a typical example, just imagine the punishment to which you subject the valves in your automobile engine when you travel for hours at an average speed of 70 or 60 or even 50 miles. Here are some of the properties required in the material used to make these valves: Great strength at temperatures approaching red heat; resistance to corrosion in the presence of hot exhaust gases; toughness, to avoid cracking; hardness to withstand wear. Nickel, chromium, silicon, manganese, tungsten and sometimes cobalt and molybdenum are combined with iron according to any one of a score of formulas. Most of the alloys include at least three of these elements in amount totaling 10 to 25 per cent. After careful heat treatment a material is produced that meets these exacting requirements remarkably well. It is fair to say that the automobiles of marvelous performance, that are commonplace to-day, could not be made except for the recent achievements of the alloy metallurgist.

Suppose we review at random some of the things with which you are familiar that depend in a vital way on alloys.

Take your radio receiving set. If your tubes burn out you cease to hear. The core of the little filament that lights up may be made of an alloy called Konel, which contains: Nickel, 73 per cent.; cobalt, 17 per cent.; iron, 6 per cent.; and titanium, 2½ per cent. A dozen vital parts of broadcasting, as well as receiving, equipment are made of alloys unknown ten years ago. Consider your telephone. You are able to make a long-distance call only because at intervals of 100 miles along the line are "repeater" stations. At these the sound waves that are your voice are amplified by vacuum tubes fitted with filaments of an alloy of platinum mixed with 5 per cent. of either nickel or cobalt. Distortion is prevented by loading coils of which the cores are a remarkable nickel-iron mixture called permalloy.

Or step into the modern kitchen. The electric range, the waffle iron, the toaster and the flatiron heat because of the electric resistance offered by a wire element made of nickel-chromium alloy. The sink, the table tops, the electric dishwasher and various containers are of attractive "white" metal. This may be an alloy called monel metal containing two thirds nickel, one third copper and a little iron; or an alloy of nickel, chromium and much iron—one of the much-talked-about group of "stainless" steels. The primary need is to resist corrosion; first, to prevent contamination of food; second, to save the energy of the housewife by keeping surfaces bright without frequent application of elbow grease for polishing.

Speaking of kitchens brings to mind eating. Many people are able to chew with passable success only because of certain tricky little structures that the dentist *now* calls "dentures" instead of just a plain "set of false teeth." For making them gold, platinum or palladium, hardened by alloying with copper or silver, are suitable. A less expensive alloy used for this purpose recently is called stellite. It contains 50 per cent. cobalt and the remainder chromium and tungsten. It is hard, tough and resis-

tant to tarnish; and, strangely enough, was first developed as a material for high-speed lathe tools because it retained its cutting qualities at very high temperatures.

You all know of the sensational developments in the field of railway transportation. To hope to compete with the airplane and the automobile, high-speed trains became necessary. Speed demanded light-weight construction, stream-line design and some type of efficient Diesel or gasoline engine for motive power. The result was the new Burlington Zephyr and the Union Pacific Streamliner, each capable of going 120 miles per hour, or twice the speed of fast steam trains. Both are made possible by alloys. The Zephyr is essentially of "stainless" steel construction; the Union Pacific train of aluminum alloy. The aluminum alloy weighs only half as much, volume for volume, as the steel alloy; but the latter has much greater unit strength and, when ingeniously put together, the finished structure weighs no more and is really stronger than the train built of aluminum. But the entire achievement, both cars and locomotives, is based on the use of special alloys.

One might explain how alloys have made modern aviation possible; how the automobile manufacturers are vitally obligated to the metallurgist; how alloys have participated in electrical-power progress; how the giant oil-refining industry depends for its success on the provision of marvelously strong and durable alloys required to make its high-pressure stills and other equipment.

As to the Army and the Navy, their effectiveness is based in large measure on alloys. A battleship, perhaps the most amazing mechanism ever made, is a complicated mass of pipes, wires and structural metal, mostly alloys of one kind and another, enclosed and protected by armor plate that is made of nickel-steel.

Contrast the crude spear of the Stone Age with the fighting airplane of today; the battle axe with the battleship. Quite as striking and significant is the contrast between the implements and mechanisms of peace in ancient and in modern times. With their furnaces and crucibles, their microscopes and testing machines of intricate variety; with their resourcefulness and patience, their ingenuity and imagination, the physical metallurgist, so-called, and his partners have wrought practical wonders surpassed by none. Thanks to them instead of stone as the one durable structural material, we have available literally thousands of useful alloys. In a real sense this difference measures progress in the material aspects of our social order.

THE BIOLOGICAL IMPORTANCE OF PRESSURE

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LIVING organisms must be constantly adapting themselves to physical changes in their environment. Among the ever varying conditions one thinks perhaps first of changes in temperature and moisture against which special mechanisms must be developed or else death ensues. There are, of course, many examples of species which exist in locations where the environment remains exceedingly constant, and under these conditions no protective mechanisms are needed. For example, parasites living within their mammalian hosts do not have to face the problem of marked variations in temperature or of moisture, and even the food supply is constant. Variations in these physical factors are also minimized for the fishes and other forms living entirely beneath the surface of the water. There are, however, other environmental factors which must be taken into consideration and of these one of the most interesting but least studied is the influence of pressure.

Pressure presents a real problem of adaptation to the fishes, for they are constantly being subjected to enormous changes as they swim in the depths of the ocean or rise toward its surface. How important these changes may be becomes evident when it is remembered that the pressure exerted by 34 feet of water is equal to one atmosphere or approximately 14.7 pounds per square inch, so that in diving that distance from the surface the pressure is doubled. Now the buoyancy of a fish is regulated to a large extent by the swim bladder, which is a sac containing air in such quantity that the specific gravity of the animal as a whole is very close to that of the liquid in which it is immersed, thus giving the most favorable weight for maintaining any position. But that is not all, for this reservoir of air directly assists its possessor to attain new levels in the water, either higher or lower; truly it is an organ of extraordinary value. The mechanism is quite automatic and very simple: The fish starts downward through swimming movements involving muscular effort, but coincident with the downward movement the specific gravity of the animal becomes constantly greater, due to the compression of the air with increasing water pressures, and gravity thus increasingly reinforces any muscular efforts. Conversely, as the fish turns upward the air expands and the animal as a whole becomes lighter than the surrounding water, so that even in the absence of further muscular effort it automatically rises to the surface. This procedure on the part of the fish is somewhat suggestive of a perpetual motion machine. Clearly, energy must be supplied from some source, a point to which we will return in a moment.

Since the volume of a gas is proportional to the pressure, the buoyant effect of the air in the swim bladder will be halved when a fish dives 34 feet below the surface. But many species normally range through depths many times greater than this; how far is not known. Certain species have been captured at depths greater than 2 miles below the surface where they would be subjected to a pressure of over 4,600 pounds per square inch. It is an old and well-known observation that when a fish is brought quickly to the surface from a considerable depth it "explodes." This is due not only to the expansion of the air within the swim bladder occurring as a direct consequence of the reduction in

pressure, but also to the dissolved gases which immediately come out of solution in a manner analogous to the bubbling of carbon dioxide from a bottle of beer on releasing the pressure. Little is known of the mechanism by which fish are able to adapt themselves to changes in pressure, but from what has been said it is evidently a process of great importance. It seems that this consists in part at least in the ability to maintain a fairly constant volume of air in the swim bladder by the absorption or excretion of gas coincident with the pressure changes. In coming to equilibrium with a new pressure work must be expanded to bring the volume of air in the swim bladder to the volume giving the correct specific gravity to the fish. Once this equilibrium is attained the animal is in a favorable position to make a quick change in its vertical position through the aid of the mechanism described in the last paragraph. Thus it becomes clear that the energy released with changes in level has its source in the potential energy stored by an unknown mechanism during the process of adjusting the quantity of air to the prevailing pressures. It should also be noted that between the time the fish reaches a new level and the attainment of an equilibrium it must make constant movements in order to prevent itself from being carried upward or downward as the case may be.

The rapidity with which pressure increases with the depth of water is of great practical importance in relation to diving operations. Workers in caissons and divers carrying on salvage work apparently withstand the relatively great pressures without difficulty. Within recent years the depth at which successful operations have been carried on has been extended to about 300 feet, where a pressure of about 130 pounds per square inch is encountered. The danger comes in returning to atmospheric pressure, and it is necessary to exercise great caution in order to avoid the sudden release of nitrogen gas from solution into the tissues where it causes serious symptoms known as the "bends" or caisson disease. The effect is analogous to the changes already mentioned which occur when deep-sea fishes are brought to the surface. In practice the serious effects resulting from a diminution of pressure are largely avoided by bringing about the change gradually so that the gases coming out of solution in the tissues may be gotten rid of as fast as formed. Various devices are now employed in deep-sea salvage work in which the diver is encased in a rigid suit, thus permitting him to carry on operations at greater depths than would otherwise be possible, because under these conditions increased pressures are avoided. Danger from caisson disease is thus eliminated and the diver may be brought quickly to the surface without danger.

It is not only the water forms of life that are subjected to pressure changes, for the whole surface of the earth undergoes variations in atmospheric pressure from day to day, and the decrease in pressure at high altitudes is very considerable. It is not probable that normal variations in pressure are sufficient to exert an appreciable influence on animal or plant life. On the other hand, birds, as well as mountain climbers, and aviators, experience large pressure changes. At an altitude in the neighborhood of 18,000 feet, which corresponds to that of some of the higher mountain peaks, the atmospheric pressure is only half that existing at sea level. Very much smaller pressure differences may be appreciated under certain conditions. Moderately rapid changes of but a few hundred feet in altitude give certain individuals definite sensations referred to the ears. This occurs because of a difference in pressure on the two sides of the ear drum which is commonly not

at once equalized because of the lack of a free communication between the middle ear and the outside.

The reduction of pressure occurring with an increase in altitude is accompanied by important changes in the concentration of the gases composing the atmospheric air, and it appears to be this factor, rather than the pressure change, which accounts for the train of symptoms known as "mountain sickness" which many individuals experience before becoming acclimated to high altitudes. Under these circumstances the study of the uncomplicated effects of low pressure becomes exceedingly difficult, and at the present time we can not say whether or not low pressure *per se* has an influence on physiological processes. On the other hand, various forms of animal life have been subjected experimentally to high pressures without serious consequences.

Gaertner, in Germany, studied the effects of increasing pressures up to 25 atmospheres on mice without observing any injurious effects, and this was true even when the pressure was applied quite suddenly. It was important, however, to release the pressure gradually if the mice were to survive. This is unquestionably due to the necessity for allowing time for the absorption of the gases escaping from solution into the tissues as the pressure is released, the situation being similar to that confronting the deep-sea divers when they return to the surface. That a high pressure is perfectly compatible with life is illustrated by the numerous deep-sea forms of animal life which inhabit the waters to a great depth. Various species of fish have been captured at depths approaching two miles, where the pressure is over 4,600 pounds per square inch. More primitive forms have been collected at still greater depths. Here there is a complete absence of light, and oxygen is present only in an exceedingly small concentration, and it is probable that the latter circumstance rather than the high pressure is the limiting factor which determines the maximum depth at which living forms can exist.

In the type of experiment which involves the exposure of the intact animal to high pressures it has been difficult to differentiate between a possible direct effect of the pressure and that due to the accompanying change in concentration of the surrounding gases, which come into equilibrium with the blood and tissues. This difficulty may be avoided and the experimental conditions simplified by using isolated tissues for the study of the effects of pressure on function. The tissue is completely immersed in a fluid through which the pressure changes are transmitted, and under these circumstances pressure can be applied without introducing changes in the concentration of the materials in the tissues or in the surroundings, except in so far as they may be the result of the volume changes in the fluid system. Fluids are commonly regarded as incompressible, but if this were strictly the case it is difficult to see how hydrostatic pressure could have any influence on the physiological processes going on within the cell. As a matter of fact physicists have found that a pressure of 1,000 atmospheres acting on a quantity of water will reduce its volume by 4 per cent. but that given increments of pressure produce smaller and smaller effects as the total pressures become greater. Accompanying the volume change are various alterations in the properties of compressed liquids. With the exception of water, the viscosity is increased, the dissociation of electrolytes is increased, and the solubility may become less or greater depending upon the system studied. These facts give a reasonable basis for predicting some influence of pressure on the function of a semi-fluid system such as a living cell.

Various workers, including Professor Regnaud (1891), in France; Sir Leon-

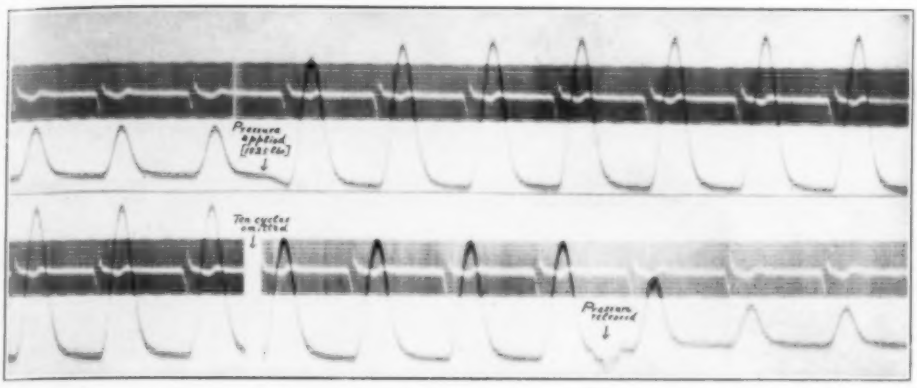


FIG. 1. PHOTOGRAPHS OF THE TENSION DEVELOPED BY A RHYTHMICALLY BEATING STRIP OF HEART MUSCLE. A PRESSURE OF 1525 POUNDS PER SQUARE INCH WAS APPLIED AND RELEASED AT THE TIMES INDICATED. THE UPPER RECORD REPRESENTS THE CHANGES IN ELECTRICAL POTENTIAL RECORDED BY MEANS OF A STRING GALVANOMETER.

ard Hill, in England (1912); and Professor Ebbecke (1914), in Germany, have studied the effect of increasing the hydrostatic pressure on the isolated muscles of the frog. They are all in agreement in indicating that pressures up to between 300 and 400 atmospheres are without immediate damaging effect on the muscle. However, when the muscle was allowed to remain under such pressures for several hours various changes were observed, including spontaneous contractions, changes in the general nature of fatigue and disorganization of the muscle structure. It is of interest to note that, with much higher pressures (6,000 atmospheres) employed by Professor Bridgman at Harvard University, egg white and ordinary meat (muscle) were coagulated at room temperature, a change resembling that occurring during the process of cooking through the action of heat. Further, it has been shown by various investigators that pressures of this order will kill bacteria. These changes are not reversible; that is, excessive pressures result in a permanent damage to the cell and so fall outside the range of normal physiological processes.

Of greater interest to the biologist is the influence of moderate changes in pressure on the functions of cells and organs. Such a study has been carried out by a group of workers in the laboratory of physiology of the Cornell University Medical College during the past few years. Thus far only a beginning has been made, but the results indicate that changes in pressure may modify physiological activity to an important extent. Some of these effects will now be described.

For the study of the action of hydrostatic pressure on muscular contraction a special chamber was constructed to withstand pressures up to 15,000 pounds per square inch. In order to study changes in the muscle while enclosed in the chamber under pressure various devices were resorted to. In the first place a heavy glass window was provided through which observations could be made. The muscle was attached to a lever upon which was a small mirror, which made possible the reflection of a beam of light into a camera. When the muscle contracted the mirror was tilted and thus a record could be made of the degree of shortening or the work done during a contraction. Further, a number of insulated electrical leads were passed into the chamber, which served various purposes at different times. Electric

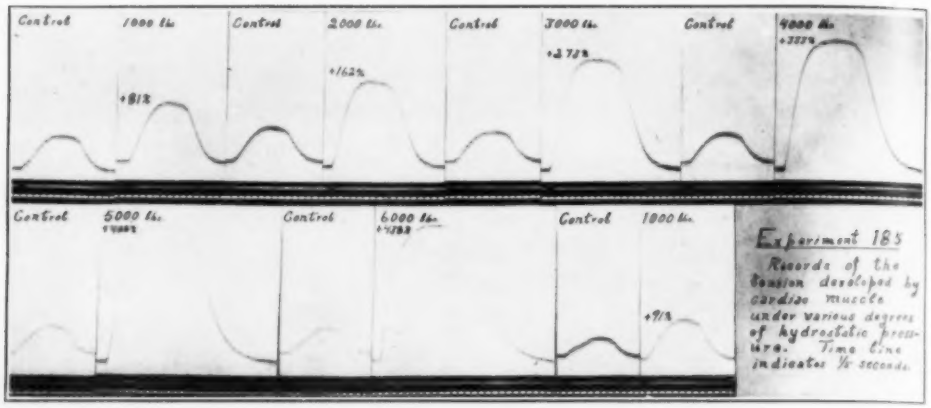


FIG 2. THE TENSION DEVELOPED BY CARDIAC MUSCLE IN RESPONSE TO A SINGLE STIMULUS AT VARIOUS PRESSURES. PHOTOGRAPHS TAKEN IN THE ORDER SHOWN, WITH CONTROLS AT ATMOSPHERIC PRESSURE ALTERNATING WITH THOSE TAKEN AT HIGH PRESSURES. PRESSURES GIVEN IN POUNDS PER SQUARE INCH.

shocks were sent into the muscle at will in order to induce a physiological contraction, and at the same time, by means of a galvanometer, the change of electrical potential in the tissue could be recorded or the heat production measured. Such in brief is the method by which we are enabled to observe muscular contraction at high pressures and to compare it with normal response taking place at atmospheric pressure.

Let us first consider the effect of increasing the pressure on a strip of heart muscle taken from the frog. Such a strip of muscle may be mounted in the apparatus and will continue its rhythmic contractions, or by properly selecting the piece of tissue a quiescent preparation may be obtained which responds with a single contraction when electrically stimulated. After studying the normal characteristics of the contraction the pressure is increased by pumping more liquid into the chamber which is transmitted throughout the entire structure of the muscle. The effect on contraction is immediate and striking in that the degree of shortening or the work done by the muscle is markedly increased. The results of such an experiment are given in Fig. 1, in which the bottom curve shows the rhythmic contractions of the turtle's auricular muscle. The muscle was attached to a stiff spring so that the peak of each of the rhythmic changes represents the pull or tension the muscle exerted and is proportional to the work done. The middle curve is a record of the electrical potential occurring in the muscle with activity and need not concern us here. In this case the application of a pressure of 1,525 pounds per square inch approximately doubled the force exerted by the beating auricular muscle.

Fig. 2 also represents the activity of the heart of a turtle, but in this case a quiescent strip of muscle from the ventricle was used. The pressure was applied in steps of 1,000 pounds per square inch up to a total of 6,000 pounds. At each pressure the muscle was stimulated and its response photographed, and this was also done in the intervals between when the muscle was at atmospheric pressure. In the figure the records are shown in the order in which they were taken. It will be seen that the stimulating action is greater the higher the pressure, the tension reaching a value at 6,000 pounds per square inch, which is more than four times that of the con-

trol. Another point which is clearly demonstrated by this experiment is that the effects of pressure are completely reversible; that is, the contraction returns to its former character as soon as the pressure is released.

Ordinary skeletal muscle from the frog may be isolated, mounted in the chamber and studied in a similar manner. When electrically stimulated such a muscle will respond with a single twitch for each electric shock. In general the effect of pressure is similar to that just described for cardiac muscle, with the difference that the changes are not so large. A typical result is shown in Fig. 3. With higher pressures the augmentation in the response becomes less and finally the direction of the influence is reversed; that is to say, the response of the muscle, at 6,000 pounds, for example, is smaller than at atmospheric pressure. At the same time the contraction is slowed, as is clearly shown in the photographic record of the twitch. Even at pressures as high as 1,000 atmospheres the twitch returns to normal when the pressure is released, provided it is not allowed to act too long.

If fatigue is produced by repeatedly stimulating the muscle or if it is cooled to a low temperature, the augmenting influence of pressure disappears and only the depressant action, just described, is observed, an effect which is now produced even by lesser pressures of the order of 60 atmospheres. As was previously mentioned, one of the most important changes resulting from the application of pressure to a fluid is a large increase in viscosity. This is true of practically all solutions except pure water which, at certain moderate pressures, has a lower viscosity than at atmospheric pressure. That high pressures do actually bring about an increase in viscosity of muscles has recently been shown by direct measurement, and it seems probable that this factor is responsible for the depression and slowing

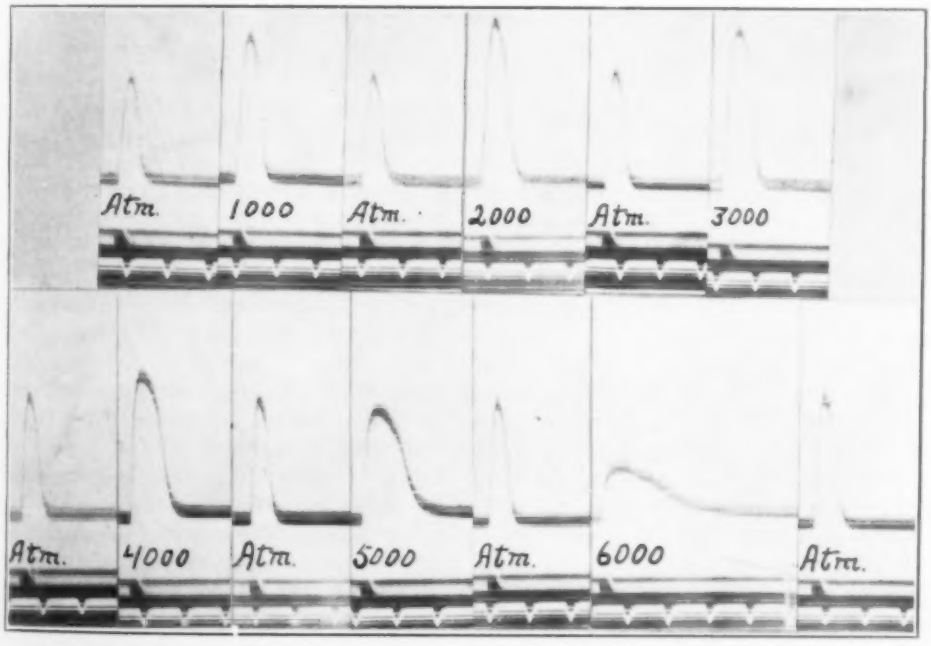


FIG. 3. THE TENSION DEVELOPED BY STRIATED MUSCLE IN RESPONSE TO A SINGLE STIMULUS AT VARIOUS PRESSURES AS INDICATED. LOWER LINE RECORDS TIME IN 1/5 SECOND INTERVALS.

of the contraction which occurs at the higher pressures. In the fatigued and chilled muscle the viscosity is abnormally high and this perhaps explains why the depression takes place at comparatively low pressures. By the combination of a low temperature and a sufficiently high pressure the size of the twitch becomes exceedingly small and may disappear altogether but recovers when the pressure is released.

The question arises as to the effect of pressure on the efficiency of the contraction. For example, is the increased tension shown in the photographs reproduced in Figures 1 and 2 due to some improvement in the conditions for transforming a given amount of chemical energy to useful work or is the effect due to an increase in the energy set free? The answer to this question comes from a study of the heat production in relation to the tension of the twitch. Since the energy of the tension developed in response to a stimulus is finally all degraded into heat with the relaxation of the muscle, the increase in temperature of the muscles gives us a direct measure of the total energy liberated. The efficiency may be represented by the ratio of the total energy to that utilized in actual work or in the development of tension. When measurements of the heat production are made simultaneously with tension records it is found that pressure results in a proportional increase of tension and heat. There is thus no evidence of an improvement in the efficiency of the mechanism through which chemical energy is converted into tension. It must be concluded that pressure causes an increased liberation of chemical energy, and it is that which is responsible for the augmentation in the size of the response.

In the case of the higher pressures which depress the muscle twitch we have, on the other hand, clear evidence of a change in efficiency. A given pressure may result in an increase in heat and a fall in tension. Under higher pressures both heat and tension become less, but the effect on the tension is always greater than that on the heat production. The magnitude of these changes denotes a maximum reduction in efficiency of about 25 per cent., which may well be due to the effects of pressure on the viscosity of the muscle substance.

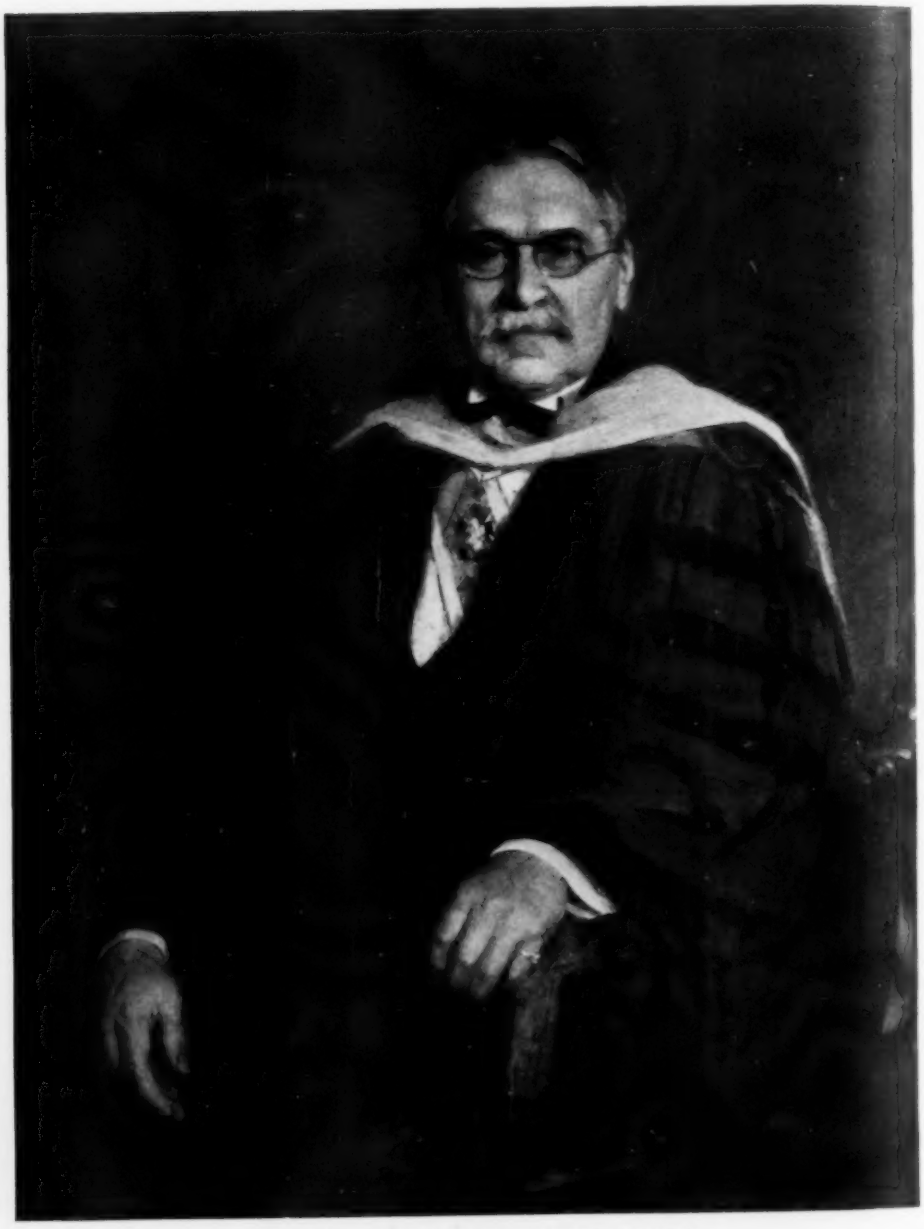
Experiments are now in progress concerning the effects of pressure on the physiological properties of nerve. Our best criterion of nerve activity is the change of electrical potential which accompanies the impulse, and this can conveniently be observed under pressure. In general the effects on nerve parallel those already described for muscle. With moderate pressures (3,000 to 8,000 pounds per square inch) we have evidence of a stimulating action in a lowered threshold of excitation, an increased velocity of propagation, and the setting up of several impulses by a stimulus normally producing but a single response. High pressures (8,000 to 15,000 pounds) markedly slow the velocity of the nerve impulse, decrease its magnitude as indicated by the action potential and raise its threshold of excitability. The interpretation of these effects is at present not clear and much further study is required.

Very much smaller pressures cause rapid loss of function when applied locally. As an illustration we may take the common experience of having a limb "go to sleep" following the prolonged application of a small pressure, *i.e.*, there is a loss of sensation and a weakness, due to failure of the nerves to function normally. This results from the changes produced in the nerve at the point of application of the pressure and may in part be due to a local interference with the blood supply. Experimentally it has been shown in isolated nerve that pressure of the order of 3 pounds per square inch, which is equiva-

lent to only a few grams on the nerve segment, will, when applied locally, completely abolish the ability of the nerve to conduct impulses within a few minutes. When a limited part of a nerve trunk is subjected to increased pressure there must always be a sharp pressure gradient at the region where the compressed portion joins that at atmospheric pressure. This results in the displacement of the fluid portions of the nerve fibers and a distortion and breaking of the solid structures. This factor is entirely absent when the organism or tissue is completely immersed in a fluid through which the pressure is transmitted, as was the case in the experiments described in the last paragraph.

A further field of study, as yet practically untouched, is the influence of high pressures on embryological development. It is a relatively simple matter to expose the eggs of such forms as the fishes or frogs to increased hydrostatic pressures. In some preliminary observations made on the eggs of the marine fish *Fundulus* it was found that the rate of cell division was slowed by pressures of the order of 2,000 pounds per square inch. In eggs containing partially developed embryos such pressures completely arrested the heart beat, which remained quiescent as long as the pressure was maintained—in some instances 24 hours—but started to beat shortly after releasing the pressure. During the period of arrested heart action the circulatory system failed to develop, and young fishes hatching from such eggs showed a high incidence of developmental abnormalities and various types of monsters were produced.

It should perhaps be emphasized that pressures of the magnitude employed experimentally can have no biological significance under natural conditions, with the possible exception of their effects on deep-sea life. A knowledge of the effects of pressure on isolated organs and tissues should, however, prove useful in evaluating the physiological importance of pressure changes in the normal environment. Further, the experimental use of the pressure technique serves as a useful tool for the study of various physiological functions. Enough has been said to indicate how very imperfect is our knowledge of the effects of pressure on biological processes. It is a fruitful field of investigation from which much may be expected in the near future.



THE LATE MICHAEL IDVORSKY PUPIN

THE PROGRESS OF SCIENCE

MICHAEL IDVORSKY PUPIN

As a telephone engineer, I am glad to have this opportunity briefly to memorialize the life and work of Michael Pupin.

Pupin early espoused that phase of physical science and engineering which underlies electrical communications, and this at a time when the needs and opportunities of the telephone and telegraph art were quite neglected by scientists generally. It is true that Heaviside had hinted at some of these possibilities in his brilliant theoretical papers, and that Vaschy in France had likewise begun to realize the importance of a thoroughgoing theoretical discussion of telephone transmission, while Kelvin at a much earlier date had made important contributions to the problem of submarine telegraphy. But the chief expounders of electrical science during the closing decade of the nineteenth century seemed little aware of the extensive and important future which awaited the electrical transmission of intelligence, and to have excluded it almost entirely from their thoughts.

We must consider it, therefore, all the more astonishing that the erstwhile young peasant of eastern Europe, where the telephone and telegraph were virtually unheard of, and who was but lately initiated into the sciences of mathematics and physics, should have chosen the field of electrical communications for his researches. The manner in which Pupin guided his early studies and researches well indicates the reaction of the alert mind to widely differing suggestions. He reached young manhood at a time when the engineering world was actively debating the respective merits of alternating versus direct current power generating and distributing systems. Pupin, fresh from his mathematical studies, was not only fascinated by this debate which drew in the leading engineers and physicists of the day, but was equally attracted by the researches with acoustical resonators which Helmholtz had been conducting. In this way he began to sense the possible analogies between the vibrating properties of sounding bodies and electrical circuits. His early work led him to the concept of electrical tuning and to the use of tuned circuits for multiplex telegraphy. Indeed, "electrical tuning" is a term which he seems to have coined. He said it was suggested by his early associations with the Serbian bagpipe, a device which fascinated him as a boy. Here were "early impressions which had made acoustical and electrical resonance appear to me later as obvious things."

Pupin was as successful in his researches as he was foresighted in selecting a field of study. Following his work in tuning and multiplex telegraphy, he made several fundamental contributions to the communications art, in particular, his famous loading coil as applied to long-distance telephone lines. With the advent of radio telegraphy, Pupin turned his attention to that field and performed much useful work in connection with the theory of rectification in general and electrolytic detectors in particular.

There were also periods when Pupin ventured into other dominions, particularly that of x-rays, where he recorded some of the earliest observed phenomena regarding production of secondary radiation.

The picturesque phases of Pupin's life—how he came to this country, a boy of sixteen, how he learned English while working on a farm, how he prepared for college by attending night classes in New York City and laboring at anything he could get during the day—are too well known and have been too

delightfully recounted in his autobiography to call for repetition here.

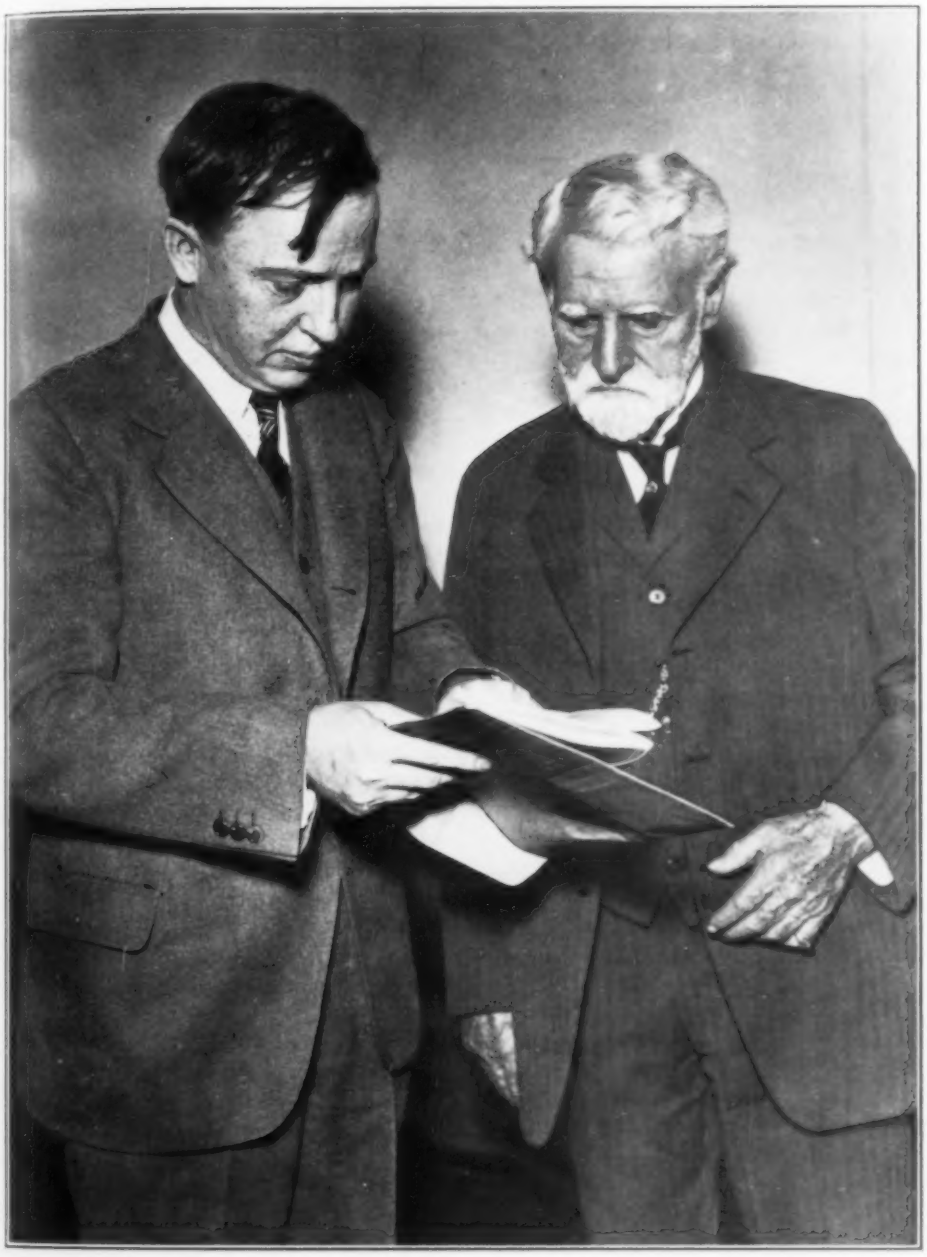
Pupin stood in the front rank of American inventors, but, like an earlier scientist whose words are often quoted, he frequently remarked that he considered his most important contributions to have been not his inventions but the young men whom, as professor of electromechanics at Columbia University, he helped to train and who later attained to eminence. As scientist, engineer and inventor, he was universally honored. As teacher, expositor or lecturer, he possessed a clarity and picturesqueness of expression, although using a language alien to that of his early training, which fascinated alike his scientific colleague and the layman. He possessed the power to write of prosaic things with the inspiration and sparkle of poetry. But above all this, and perhaps of even greater importance at a time like the present when political creeds of every sort are tumbling about us, and even the fundamental doctrine of democracy is being viciously assailed, we would do well to regard Pupin's sturdy and uncompromising loyalty to the American political ideal. He found in the liberal and tradition-free life of America an atmosphere in which his faculties could reach their widest scope, and in gratitude he strove passionately to help others of his countrymen who followed him across the ocean to attain as great a measure as might be of free and independent life.

FRANK B. JEWETT

THE SOIL MECHANICS LABORATORY AT HARVARD UNIVERSITY

THE use of earth either for construction purposes (*e.g.*, dikes, dwellings) or as a foundation for carrying structures is as old as the beginnings of human civilization. For centuries builders have witnessed gradual or sudden subsidences of their structures, sometimes with disastrous consequences, in most cases knowing all too well that the cause resided in the character of the soils on which they built. It is a perplexing fact that this tremendous amount of human experience did not crystallize into a scientific approach to the mechanics of soils until about fifteen years ago. Even to-day by far the greater proportion of earth and foundation engineering is based on purely empirical knowledge, without utilizing the possibility of analyzing stresses, strength and deformation of the soil with the help of modern soil mechanics.

Such empirical designs are only too often pure guesswork, resulting, in most cases, in a large waste of money due to overdesigning, or, occasionally, in structures that are unsafe. This condition is not entirely the fault of the engineers engaged in construction work. Just as the great complexity of the physical properties of soils and their almost infinite variety is responsible for the unusually delayed development of a science of soil mechanics, so the difficulties of this new science in its present stage of development and the requirements of a specialized training have delayed its wide-spread application. To master the subject sufficiently to be able to apply it to actual design and construction requires much more knowledge than can be gained from a theoretical course in soil mechanics. In addition, a thorough training in soil identification and in the technique of soil-testing methods is necessary. Such training can be acquired only by working for at least one year in a well-equipped laboratory under the guidance of leading men in this field. Furthermore, successful participation in research is, as experience has shown, a necessary part of the training of students who wish to become proficient in dealing with the many new problems and new types of soils that one constantly encounters in earth and founda-



DR. HARLOW SHAPLEY AND DR. AMBROSE SWASEY

DR. HARLOW SHAPLEY, DIRECTOR OF THE HARVARD OBSERVATORY, WHO GAVE THE EVENING LECTURE AT THE CLEVELAND MEETING OF THE NATIONAL ACADEMY OF SCIENCES, WITH DR. AMBROSE SWASEY, THE DISTINGUISHED CLEVELAND MECHANICAL ENGINEER AND DESIGNER OF TELESCOPES, IN WHOSE HONOR THE YERKES OBSERVATORY RECENTLY NAMED A NEWLY-FOUND ASTEROID "SWASEYA," ON THE OCCASION OF HIS EIGHTY-EIGHTH BIRTHDAY.

tion engineering. At present the number of men in the United States capable of such independent work reaches hardly one dozen. What an unusual opportunity for keen students to work themselves into a new and fascinating field with rapidly expanding opportunities in engineering, research and teaching!

Realizing that it is up to the engineering schools to train such specialists, Dean H. E. Clifford, Professor G. M. Fair and Professor A. Haertlein, of the Graduate School of Engineering at Harvard University, supported, with admirable initiative, the reorganization of studies in earth and foundation engineering, including all related subjects, on the basis of a thorough training in soil mechanics. This plan included the installation of a research and instruction laboratory, which was started two and a half years ago and is now practically complete.

Since soil-testing methods and apparatus are still in a state of rapid development, extensive studies and research were devoted to the design of the equipment of this new laboratory. As a result new apparatus were developed which contain so many decided improvements that they represent a remarkable progress in soil testing. Those features of older designs which were found to cause appreciable errors were eliminated, and other improvements were added for further increase in accuracy and for reducing the work required to perform the tests. In addition, other developments were carried out chiefly for the purpose of permitting the performance of necessary specialized research.

Probably the most important single soil test is the consolidation test, in which a cylindrical soil sample, laterally confined, is gradually compressed between porous plates. Its main purpose is to measure the rate and magnitude of volume decrease of clays and other fine-grained soils, for analyzing settlements of buildings and other structures. The development of this testing method and of the theory of consolidation of fine-grained soils, on which it is based, form an important part in the great achievements of Professor Karl von Terzaghi (Vienna, Austria), the founder of modern soil mechanics and its leading authority.

Shearing tests and unconfined compression tests permit the determination of the strength of soils. This must be known when analyzing the safety of natural and artificial slopes against movements and slides. The method of observing the volume of the sample during shearing tests, introduced by the author five years ago, has been further improved. Among the important findings to which this method has led may be mentioned the application to the mechanics of land slides. It was found that sand and gravel expand during shearing tests, while fine-grained soils, such as rock flour, or still finer soils, reduce their volume. In other words, fine-grained soils, after being deformed, must consolidate further to be able to carry the same load as before deformation. If this consolidation is delayed or prevented, it means that a part of the load or the entire load must be carried by the water in the voids, thus reducing the shearing resistance of the soil temporarily to a very small value or to zero. If horizontal forces are acting (hydrostatic forces, unsymmetrical distribution of masses or inclined stratification), then the reduced shearing resistance may result in the movement of large masses of soil. The danger of land slides of this type is always great in clay deposits that contain thin layers or partings of very fine sand or rock flour.

An outstanding single feature of the new laboratory is the development of a universal soil-loading machine, on the framework of which all the important soil tests can be performed. This results in large savings in laboratory space, in the cost of numerous separate loading devices, and, last but not least, in work-

ing time. The following tests can be performed on this universal machine:

(1) *Consolidation tests:* Three such apparatus are seen in Fig. 1 on the left side of the bench; by using the entire loading bench six consolidation tests can be performed simultaneously.

(2) *Direct shearing tests:* One shearing frame can be seen to the right of the consolidations apparatus. Above the shearing frame one can see the beam which permits an automatic application of the shearing force at any desired rate. This beam is mounted on a carriage which can be moved laterally to operate at any point along the bench. Thus while samples are being prepared or while they are consolidating in other apparatus, the shearing beam can be used for testing those samples which already have reached the desired degree of consolidation.

(3) *Unconfined and semi-confined compression tests:* The loading beam, yoke and bearing plate are permanently mounted on the right end of the universal machine. However, they can be used for numerous other purposes, and in Fig. 1 this part of the equipment is being used for a consolidation test.

(4) *Direct permeability tests* for water pressures up to thirty feet. The permeability attachment is mounted on a vertical board, seen to the right of the shearing beam. It consists of a combination of a graduated standpipe, mercury manometer and air pressure tank. This device can be moved so as to operate at any position along the bench.

The laboratory includes a humid room with automatic humidity control, and is, in addition, equipped with many instruments and devices, either for soil testing and soil classification, or for demonstration and instruction purposes. With the latter, experiments can be performed with ordinary sand that are startling not only to the layman but even to experienced foundation engineers. For example, dry sand is poured into a thin rubber bag connected to a vacuum pump. As long as the air pressure on the outside and inside are the same, the bag feels very soft and the sand within can readily be moved around or deformed. However, as soon as most of the air is removed from the interior with a few strokes of the pump, the bag turns as hard as a piece of rock. Such is the effect of the weight of soil itself on the character of cohesionless sand. This experiment demonstrates simply how such sand would feel at a depth of, say, ten feet, and why the bearing capacity of sand increases very rapidly with depth. Another device consists of a tank filled with fine sand and equipped with water connections. By changing the flow of water one can demonstrate the principle of quicksand. One can also show with this device the danger which lies in producing vibrations in loose, saturated deposits. A heavy load is carried by the sand surface without any noticeable impression. Yet a slight vibration produced by driving a model pile into the sand suddenly liquefies the whole mass

THE SOIL-LOADING MACHINE

WHICH IS CARRIED BY LARGE I-BEAMS SUPPORTED IN THE WALL, THUS ELIMINATING ALL FLOOR VIBRATIONS. THE LOWER BEAMS FORM THE LOADING BENCH ON WHICH THE SOIL-TESTING APPARATUS ARE SET UP.

of sand and the weight disappears. It is beyond the scope of this communication to go into a detailed explanation of the mechanics of these phenomena.

Among the research projects which are in progress at this laboratory, the following are of considerable importance:

(1) A comprehensive investigation of the shearing resistance of soils, including undisturbed clays.

(2) An experimental and theoretical investigation of the consolidation characteristics of undisturbed clays with particular attention to the structure of the clay and the effects of temperature.

(3) An investigation of the stress-strain characteristics of undisturbed clay beneath footings and its relation to the stress-strain characteristics of unconfined clay cylinders.

(4) Investigation of frost action in soils, rocks and building stones.

(5) Investigation of seepage through and beneath dams with particular attention to stratification and joint planes between soils of different permeability.

ARTHUR CASAGRANDE

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THE FALL OF A GIANT SEQUOIA

AN ordinary tree of the forest dies and little thought is given it. Trees in such infinite numbers sprout, mature, succumb to fire, insects, decay or other agencies; but when a two-thousand-year-old Giant Sequoia goes thundering earthward there is a sadness akin to losing an old friend.

The well-known Stable Tree measured the 246 feet of its length across the forest floor of the Mariposa Grove of Big Trees last August 28. Two early morning tourists on the road a hundred yards distant saw the fall, heard the crash, but because such a cloud of dust was produced by this twenty-four-foot diameter giant they didn't get out of their car! As they left the grove they casually mentioned the occurrence to the ranger. Two employees of the Big Trees Lodge, some three hundred yards distant, noticed a sliding door rattling. Thus was another monarch fallen. Rains, a few days previous, had loosened its shallow roots; a great fire scar which formed a cavity fifteen feet in diameter had removed more than one third the tree's base support; gravity did the rest. These *Sequoia gigantea* do not know how to die standing. This Stable Tree seemed flourishing. Its numerous branches and green foliage were full of newly forming cones.

The name "Stable Tree" was applied during stagecoach days. Located one hundred yards from the old log cabin, now remodeled and used as a museum, it was equipped with mangers and accommodated four horses comfortably. We marvel at changes which have taken place during the seventy-seven years this grove has been known to us. Seventy-seven years seems so short a span when we consider this tree has lived through the entire Christian era. If an individual tree rehearses the history of its race, then the Stable Tree must have been a good-sized sapling when Christ was born; it must have been approximately two feet in diameter when the Roman Empire was at its height; it must have been ten feet in diameter at the time of the first Crusade; and it must have reached practically its present size by the time the Pilgrims landed in New England.

This is the third of the grove's very large trees which have fallen during our time: The Fallen Giant, 1873; the Massachusetts Tree, 1927, and the Stable Tree, 1934. These three are all within a distance of one hundred yards of each other. Great fire scars were perhaps the principal factors contributing to their fall.

THE GIANT SEQUOIA IN THE OLD STAGECOACH DAYS

WHEN IT WAS USED AS A STABLE. IT WAS EQUIPPED WITH MANGERS AND WOULD ACCOMMODATE FOUR HORSES. THE PHOTOGRAPH WAS MADE FROM AN OLD NEGATIVE TAKEN BY THE PIONEER PHOTOGRAPHER, HOYT.

THE END OF THE GIANT SEQUOIA

Recent studies conducted by our Naturalist Department have contributed valuable information concerning the accurate dates, extent and severity of forest fires which must have raged through this grove. By scraping away the charcoal in these deep burns and by use of an increment borer, all fires attacking any given tree can be accurately determined and dated. We know, for example, that the last severe fire was in 1862 and prior to that, severe fires burned in the Stable Tree area in 1803, 1742, 1710, 1690, 1652, and so on back to A.D. 450, which at present is the earliest fire we have been able to date. It was the fire of 450 that so severely burned through the heart of the Haverford Tree, which is less than two hundred yards from the Stable Tree. It was this fire and other fires prior to 1710 which did the major portion of the burning into the great base of the Stable Tree. A comparison of these fire dates shows intervals of 59, 39, 32, 20 and 38, or an average interval between fires of 38 years for the 210 years prior to 1862. The fact that there has been no major fire during the past seventy-two years shows the important result of our fire protective measures.

The Stable Tree, prostrate, still lives as an exhibit. Thousands will marvel at its great size, the thickness of its bark and especially its remarkable resistive and self-healing powers that have made it able to live and grow in spite of tremendous injuries. It was not affected by insects; it resisted elements of decay. Its powers of resistance will remain to preserve it yet many years.

C. A. HARWELL,
Park Naturalist
YOSEMITE NATIONAL PARK

ATMOSPHERIC ACOUSTICS AND THE WEATHER[1]

EVERY boy who has lived in the country knows that the distinct audibility of far-away trains or crowing cocks is an almost infallible sign of an approaching storm. Even the city dweller must have noticed that the hissing noise of the steam shovel or the rattling noise of the compressed-air riveter can be heard further and louder on a cold dry day in winter than on a hot sultry day in summer. These and many other common observations connecting the weather and the acoustic "transparency" of the atmosphere recently have been clarified by experiments on the absorption of sound in gases.

These experiments began five years ago with certain difficulties which were encountered in calibrating the new reverberation rooms at the University of California at Los Angeles. When the dry air from the desert lowered the relative humidity in the room to from 10 to 15 per cent. a high-pitched tone (4,000 vibrations per second) was observed to die away to inaudibility in 2.5 seconds, whereas when the humid air from the ocean filled the room this same tone would remain audible as long as 4.5 seconds. By measuring the rate of decay of sound in two reverberation rooms—one a large room and the other a small room, both finished with painted concrete—it was possible to determine the rate of absorption of sound in the air for different temperatures and humidities. Such measurements revealed the surprising result that high-pitched sounds, when propagated through the air, are absorbed from 10 to 100 times faster than had been predicted by the classical theories of Stokes and Kirchhoff—theories that had been generally accepted by physicists for the past two generations—and the absorption was found to depend upon temperature and humidity in a characteristic manner. For each sound frequency there is a certain humidity (low humidities for low-pitched tones and higher humidities for high-pitched tones) for which the air is more "opaque" than at any other humidity. Perfectly dry air is the best conductor of sound, and the colder the air the better the conductivity. This

[1] A non-technical statement of the work reported by the author at the Pittsburgh meeting of the American Association for the Advancement of Science. His paper entitled "The Absorption of Sound in Gases" was awarded the Association Prize of $1,000.—ED.

EXPERIMENTS IN THE MOJAVE DESERT

GRADUATE STUDENTS, MR. L. P. DELSASSO AND THE AUTHOR MEASURING THE ATTENUATION OF SOUND AS IT IS PROPAGATED OVER A DRY LAKE IN THE MOJAVE DESERT. A "POINT" SOURCE IS MOUNTED ON THE TOP OF A POLE AND THE OBSERVERS MOVE RADIALLY AWAY FROM THE POLE UNTIL THE TONE IS REDUCED TO THE THRESHOLD OF AUDIBILITY. THESE EXPERIMENTS ARE BEING CONDUCTED TO CHECK THE RESULTS OBTAINED IN THE LABORATORY.

helps to explain the long-distance transmission of sound in the Arctic, where reports from reliable observers indicate that the ordinary sounds of speech or the barking of dogs can be heard over distances as great as ten to fifteen miles. Whereas dry, cold air is more "transparent" than any other kind of air, the addition of small amounts of water vapor or an increase in temperature greatly decreases the acoustic transparency of the air. The addition of larger amounts of water vapor (above a relative humidity of about 20 per cent.) increases the transparency again. Hot, desert air containing a relatively small amount of water vapor stifles sound more than any other kind of air does.

The experimental findings of this investigation have an immediate and important application in architectural acoustics and sound signaling. The measurement of the absorptive properties of acoustical materials, for frequencies above 500 cycles per second, can now be accomplished without introducing errors, owing to an unknown or variable absorption in the air, which in some instances have been very serious. In large auditoriums, the reverberation of the high frequency components of speech and music is affected more by the condition of the air in the room than it is by the nature of the materials which form the boundaries of the room. Thus, at a frequency of 10,000 cyles—which is now generally regarded as lying within the range of frequencies necessary for high quality sound—the value of the absorption coefficient in the air at 70° F. and 18 per cent. relative humidity is 0.020 per foot. This means that a plane sound wave of this frequency would have its intensity reduced more than 60 per cent. in traveling a distance of 50 feet. Of course, this low humidity is rarely realized in a room occupied by people, but even at a relative humidity of 50 per cent. the absorption at these high frequencies is very great—so great that it is necessary to reckon with the phenomenon of sound absorption in air in the design of sound-reproducing equipment, especially for large theaters or out of doors.

Sound signaling in the air by means of high frequency beams encounters serious limitations because of the absorption in the air. For example, at a temperature of 70° F. and a relative humidity of 14 per cent., the value of the absorption coefficient at 6,000 cycles is 0.012 per foot. Under these circumstances such a beam of sound would be reduced to one millionth of its initial intensity after traveling a distance of about 1,200 feet. It is obvious, therefore, that such a high frequency sound is not suitable for acoustic signaling, as, for example, for acoustic altimeters in aircraft. Tones of lower frequency—about 2,000 cycles—are more suitable for long-range signaling. The most favorable frequency will not be the same for different conditions of temperature and humidity, but for known weather conditions it is possible by means of these recent experiments to calculate the most favorable signal frequency.

The theoretical interest in these new results is perhaps even more significant than their practical applications. Thus, the experimental results have been satisfactorily explained by Dr. H. O. Kneser, of Marburg, Germany, by assuming that collisions between oxygen molecules and certain other molecules, as water molecules, result in the transfer of translational and vibrational energy. A new technique is thus available for investigating molecular phenomena. Already, interesting data have been obtained concerning the nature of the forces involved in molecular collisions, and it is in this field that the new experiments on sound absorption promise to be most useful.

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